Use of Nintendo Wii™ (Wii) gaming console for rehabilitation of children with cerebral palsy

Dissertation submitted to the Tamil Nadu Dr. M.G.R. Medical University, Chennai, Tamil Nadu, in partial fulfillment of the requirements for the MD branch XIX (Physical Medicine and Rehabilitation) University Examination in April 2015

CERTIFICATE

This is to certify that the dissertation titled **"Use of Nintendo Wii™ gaming console for rehabilitation of children with cerebral palsy"** is the bona fide work of **Dr. Jane Elizabeth Sajan** (registration number 20116501) in partial fulfillment of the requirement of the Tamil Nadu Dr. MGR University, Chennai, for the MD branch XIX (Physical Medicine and Rehabilitation) for University Examinations in April 2015.

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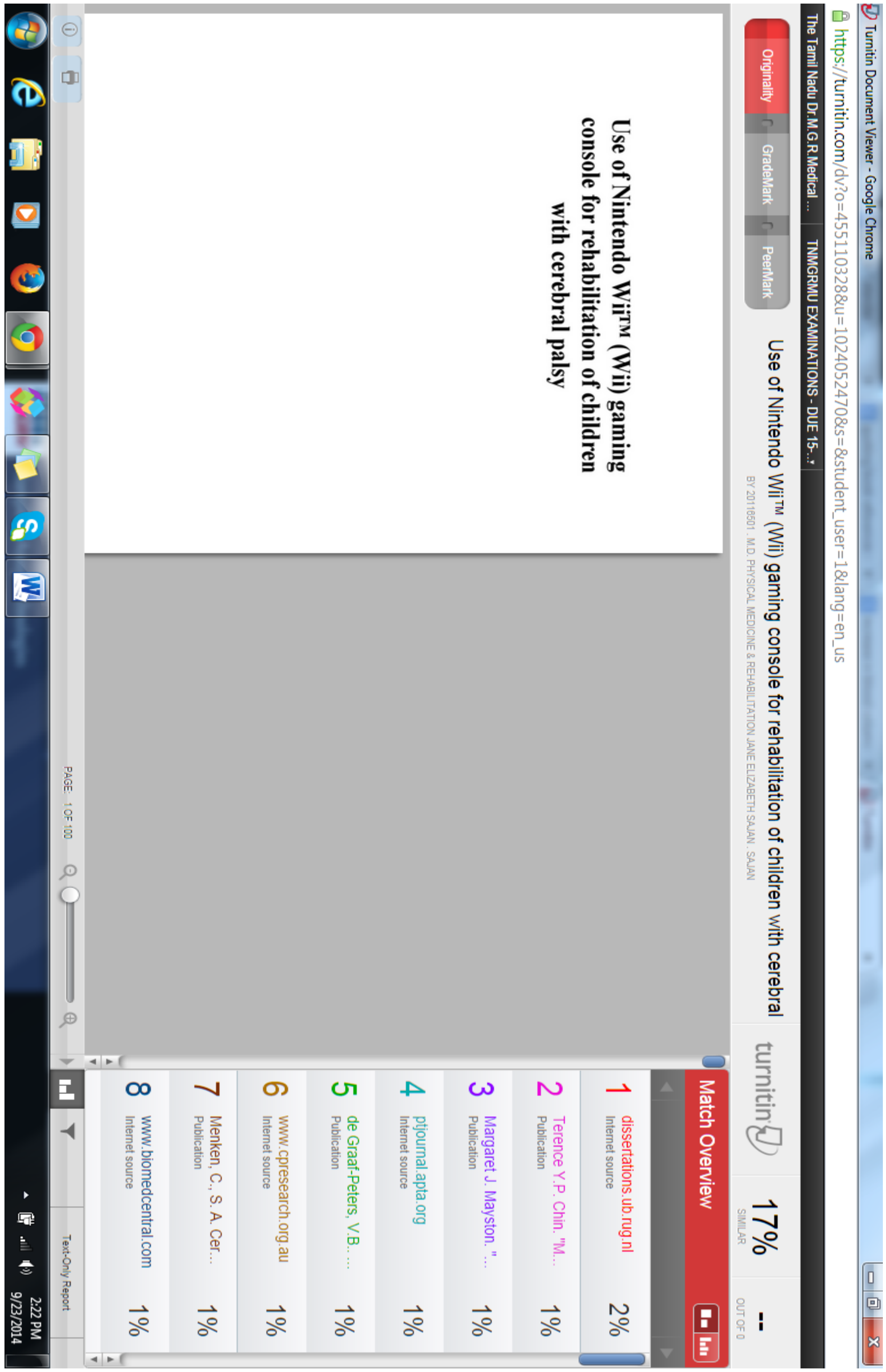
Jane Elizabeth Sajan

TURNITIN ORIGINALITY CERTIFICATE



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Title: Use of Nintendo Wii™ (Wii) gaming console for rehabilitation of children with cerebral palsy.

Department: Department of Physical Medicine and Rehabilitation (PMR), Christian Medical College, Vellore

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Degree and subject: MD – PMR

Name of Guide: Dr. George Tharion

Objective:

To evaluate the potential of using Nindendo Wii, a commercially available gaming console, as an adjunct to routine therapeutic regimen, in the rehabilitation of children with cerebral palsy (CP).

Methods:

The study was designed as a pilot randomized controlled trial with 20 CP children. The children in the intervention group played Wii games for 18 sessions in 3 weeks as part of their routine therapy. The children in the control group received routine therapy alone. The outcome measures were posture control and balance, upper limb and hand function, visuoperceptual skills and walking speed and endurance. These were measured before and after the intervention in each group. The Wilcoxon signed-rank test (for paired data) and Mann Whitney tests (for independent variables) were used for statistical analysis of the data.

Results and conclusion:

A significant improvement in upper limb and hand function was seen in the post-test compared to pre-test in the intervention group, which was not seen in the control group. No statistically significant effects of the intervention were seen on the other outcomes measured compared to the control group. Children in the intervention group were highly motivated and enjoyed playing Wii games as part of their therapy sessions. We conclude that Wii games-based therapy may be offered as an effective adjunct to routine therapy in CP rehabilitation. However, larger studies will have to be done in order to come to definite conclusions regarding the beneficial effect of this intervention.

Key words: cerebral palsy; rehabilitation; Nintendo Wii; virtual reality; posture control; upper limb and hand function; visuoperceptual skill; functional ambulation

Aim of the study:

The aim of this study is to evaluate the potential of using the Nindendo Wii™ (Wii), a commercially available gaming console, as a supplement to routine therapeutic regimen, to improve posture control, upper limb and hand function, visual-perceptual skills and functional mobility in children with cerebral palsy.

Objectives of the study:

This study is designed to assess whether a three-week, 45 minutes per day program of virtual reality gaming using the Nintendo Wii™ gaming console for children with cerebral palsy improves:

1. posture control, as assessed by static posturography and the Paediatric Berg's Balance Scale (BBS).
2. upper limb function and gross manual dexterity, as assessed by the box and block test and Quality of Upper Extremity Skills Test (QUEST)
3. visual perceptual skills, as assessed by the Test for Visual-Perceptual Skills, 3rd edition (TVPS-3).
4. functional mobility, as assessed by walking distance and speed measurement.

Introduction

INTRODUCTION:

Cerebral palsy (CP) is a condition characterized by impaired movement and posture due to a non-progressive lesion to an immature brain. The injury could occur prior to birth, during delivery or before 2 years of age. It is often accompanied by disturbances of sensation, cognition, communication, perception, behavior, or by a seizure disorder. CP is one of the most common pediatric conditions associated with serious motor disability. The reported incidence is approximately 1.5 - 2.0 per 1000 live births. The overall prevalence of CP has remained constant in recent years despite increased survival of at-risk preterm infants.

Posture and balance problems in these children are major limiting factors in motor development and performance of everyday activities. Improving posture control and balance is therefore a major aim of therapy in these children. Upper limb and hand function is another area where improvements are critical to enhance the ability of these children in activities of daily living.

Most of CP children who get routine therapy at an institutional level find it difficult to maintain the same at home. Parents attribute this poor compliance partly to the mundane nature of the activities required as part of therapy. The primary purpose of virtual reality games in therapy for CP children is to improve competence and confidence in motor-based activities through engagement in interactive games in a safe and controlled environment, which are inaccessible to these children in the real world. In addition, the fact that it involves game-based activities that are naturally interesting to children makes it highly likely that their motivation and compliance to therapeutic regimen would be high.

Nintendo Wii (Wii) is one of the most common home-based virtual reality gaming consoles available commercially. There are very few studies which have looked at the utility of Wii in rehabilitation of children with CP. In 2008, Deutsch et al published a case report in which Wii was used in rehabilitation of a 13-years-old child with spastic diplegic cerebral palsy. They reported improved posture control, visual-perceptual skills, and mobility. However, there have not been additional studies since then to provide further evidence on the possible beneficial role of Wii in improving posture control in children with CP.

This study was therefore designed as a pilot, randomized controlled trial to assess the clinical utility of Wii in rehabilitation of CP children. Improvement of posture control and balance was the primary outcome studied. Improvements in upper limb and hand function, visual perception and function mobility were the secondary outcomes studied.

Review of Literature

REVIEW OF LITERATURE

Cerebral palsy (CP) is a condition characterized by impaired movement and posture due to a non-progressive lesion to an immature brain. The injury could occur prior to birth, during delivery or before 2 years of age (Frontera, n.d.). It is often accompanied by disturbances of sensation, cognition, communication, perception, behavior, or by a seizure disorder (Bax et al., 2005).

Physician William John Little was the first person who described about Cerebral Palsy in his case report in the year 1843. The term ‘Cerebral Palsy’ was coined by Sir William Osler in 1889. It was Sigmund Freud in 1968 who gave a detailed description of the condition. Winthrop M Phelps who was the first President of the American Academy for Cerebral Palsy proposed a holistic approach for CP management.

Change in muscle tone and posture, both at rest and with voluntary activity, is the most characteristic feature of this condition. By definition, the injury underlying the pathologic process in the brain is non-progressive and has occurred during early brain development. In general, the upper age limit for the injury to have occurred is the second year of life. However, it is not clear what the upper age limit could be set for post neonatal brain injury (Braddom, n.d.).

EPIDEMIOLOGY

CP is one of the most common pediatric conditions associated with serious motor disability. The reported incidence is approximately 1.5 - 2.0 per 1000 live births. The overall prevalence of CP has remained constant in recent years despite increased survival of at-risk preterm infants (Oskoui et al., 2013).

Risk factors associated with CP can be classified as:

a. General: gestational age less than 32 weeks and birth weight less than 2500 g.
b. Maternal: history of seizure disorder, mental retardation, hyperthyroidism, two or more prior fetal deaths, sibling with motor deficits
c. Gestational: twin gestation, fetal growth retardation, third trimester bleeding, premature placenta separation, low placenta weight, chorionitis, increased urine protein excretion
d. Fetal: abnormal fetal presentation, fetal malformations, fetal bradycardia, neonatal seizures

CLASSIFICATION

CP is classified into the following groups:

- Spastic (pyramidal) CP (75%)
- Dyskinetic (extrapyramidal) CP (7%)
- Ataxic CP (5%)
- Hypotonic CP (0.5%)
- Mixed type (combination) CP (2.5%)

PATHOPHYSIOLOGY OF MOTOR DISORDERS IN CEREBRAL PALSY

Many years of research exploring the pathological mechanisms that underlie cerebral palsy has provided a lot of information on many aspects of the pathogenesis of this condition. However, a lot of information is conflicting and contradictory. There is still very little clarity on the basic pathophysiology of the condition. Some of the major theories that have been described are discussed below:

1. Lack of cortical control of spinal motor neurons:

Transcranial magnetic stimulation (TMS) studies have shown that corticospinal projections to the motor neuron pools of the distal upper limb muscles from the motor cortex is decreased or absent in children with cerebral palsy (5–7). Cutaneo-muscular reflexes (CMRs) help to assess the activity of the spinal and transcranial pathways. This has been used to study cortical control over spinal motor neurons (Jenner & Stephens, 1982). Using this method, it has been shown that the spinal response predominates when digital nerves of children with spastic CP are stimulated (Evans et al., 1987; Gibbs et al., 1999b). This shows that cortical control is impaired in these children. The lack of cortical control can explain in part the impairment of voluntary and postural activity found in this group of children. This will also result in an impairment of feed forward or anticipatory control of both postural and task-related activity (Eliasson et al., 1992; Brogren et al., 1996). Cortical control is crucial for voluntary control of finger movement and coordination. Therefore, absence of cortical control results in an inability to perform tasks that require precise hand and finger movement (Carr et al., 1993; Lemon, 1993; Galea & Darian- Smith, 1997).

2. <u>Re-organization of corticospinal projections</u>:

When the injury resulting in cerebral palsy occurs very early in gestation (before 24 weeks), it has been seen that the corticospinal projections re-organize to adapt to such injury. It has been shown in children with spastic hemiplegia that corticospinal neurons from the intact hemisphere branch out such that motor neuron pools of homologous upper limb muscles of both sides are innervated (Carr et al. 1993). This has also been shown in children with spastic quadriplegia associated with very preterm birth (Mayston et al., 1995). The practical consequence of such re-organization is that this will result in simultaneous activity of both hands when these neurons are stimulated. This may be of advantage in certain circumstances, however, performance of tasks that require bimanual activity will be severely impaired.

3. <u>Lack of coordination between agonist and antagonist muscle pairs.</u>

Normally, agonist and antagonist muscles either co-contract (e.g., to stabilize a joint) or act reciprocally (to allow movement to occur). In young children, agonist-antagonist muscle pairs tend to co-contract early on and reciprocal activity of these muscle pairs are developed later on. In CP, agonist-antagonist muscles tend to co-contract and rarely act in a reciprocal fashion (Berger et al., 1992; Brogren et al., 1998; Forssberg and Hirschfeld, 1994). This is thought to be due to the absence of corticospinal projections that would normally facilitate the action of Ia inhibitor interneurons (Leonard et al., 1990; Mayston et al., 1996; 1998; O'Sullivan et al., 1998). In contrast, dorsal and ventral trunk muscles tend to act reciprocally at first and this is replaced with co-contraction as postural control develops. This facilitates independent limb movements for postural and manipulative skills

(Forssberg and Hirschfeld, 1994). This pattern of contraction of agonist and antagonist muscles is disturbed or inconsistent in CP (Brogren et al., 1998; Nashner et al., 1983).

POSTURAL DYSFUNCTION IN CP

Postural problems are of major concern in CP as postural deficits influence the ability to perform normal daily activities. Apart from severity of disability, biomechanical factors, such as the size of the support-base, can also influence the ability to control posture. The postural problems are pronounced in the standing position due to the small support-base and therefore, many children with CP spend large majority of their time in the sitting position. Improving posture control is therefore one of the major aims of management of CP.

Basic principles of postural control and its development

Postural control refers to the ability of the body to maintain equilibrium and keep the center of pressure (CoP) within the limits of stability at rest as well as during movement (Massion, 1998).

Posture control is an extremely complex task. In order to keep a multi-joint body upright on a relatively small support base (the feet), a great amount of synchronization and synergy of muscular action is required. The complexity of this task is countered by the nervous system by creating motor synergies. This means that pre-structured neural commands at the spinal and brain stem level synergize the activity of multiple muscle groups in order to maintain posture without the involvement of higher centers. It has been suggested that the neural control of these motor synergies exist at two levels (Forssberg and Hirschfeld, 1994).

Level 1: Direction-specific adjustments

Direction specificity refers to the fact that any movement resulting in a forward sway (example, reaching forward), would be accompanied by postural activity in the muscles of the dorsal aspect of the body, and vice versa (Forssberg and Hirschfeld, 1994).

It has been suggested that basic direction-specific postural adjustments may be innate in origin (Hedberg et al., 2004). Studies have shown that direction-specific postural adjustments is seen in infants as young as one month and is a consistent feature in infants who are 7 to 8 months old (Harbourne et al., 1993). Electromyographic (EMG) studies have shown that reaching movements in infants are initially not accompanied by direction-specific postural adjustments (Van der Fits et al., 1999b). However, by 4 to 5 months of age, 50% of reaching movements are accompanied by such adjustments in the dorsal postural muscles. This is associated with increasing “success” in grasping or touching the item that the infant reaches out for, thus suggesting that direction-specific postural adjustments increases the accuracy of reaching movements in infants (de Graaf-Peters et al., 2007a). By 2 years of age, reaching activity in the sitting posture is always associated with direction-specific adjustments (van der Heide et al., 2003). In the standing posture, such activity develops by around 14 months when infants are capable of standing independently and is fully developed in young children more than 2 years of age (Sveistrup and Woollacott, 1997).

Level 2: Fine-tuning of the basic postural pattern:

This refers to fine adjustments of posture (variation) that is based on multi-sensorial afferent input from somatosensory, visual, and vestibular systems. Such fine adjustments may be related to muscles which are recruited, the order in which they are recruited or the degree to which they are contracted (Hadders-Algra, 2000).

Recruitment of all direction-specific muscles in concert (the complete pattern) develops in a consistent fashion after 3 to 4 months of age. This development is complete by 2 years of age and remains the preferred pattern into adulthood (Forssberg and Nashner, 1982; Woollacott et al., 1998). However, the muscles used in a given situation depend greatly on nature of the postural task. For example, the complete pattern is used more when an external force challenges balance than in a planned motor activity. In addition, activities in the standing posture elicit a complete pattern more often than those done in the sitting posture.

The order in which muscles are recruited in postural adjustment displays particular patterns that develop with age. In infancy, the preference is for a top-down pattern with the neck muscles recruited first (de Graaf-Peters et al., 2007b). In older infants who sit independently, a bottom-up pattern is seen recruitment (Van der Fits et al., 1999b). In pre-school children the recruitment pattern is variable but a top-down pattern emerges during reaching movements in the sitting posture. This pattern becomes established by puberty (van der Heide et al., 2003). In the standing posture, the bottom-up recruitment pattern is seen at 8 to 10 months of age and persists into adulthood. This pattern is particularly evident when external forces disturb balance (Forssberg and Nashner, 1982; Woollacott et al., 1998). In general adults have a variable recruitment pattern during voluntary movement in the standing posture (Aruin and Latash, 1995).

Co-activation of antagonist muscle when balance is disturbed in the standing position is first seen at 1.5 to 5 years of age (Berger et al., 1995). Beyond this age, reciprocal inhibition of antagonist muscle is seen (Sundermier et al., 2001).

The ability to modulate amplitude of EMG activity (strength of contraction) is one of the most subtle forms of fine-tuning postural control (Van der Heide et al., 2003). This ability starts to emerge at 9 to 10 months of age. By this, infants in the sitting position regulate postural muscle activity based on the speed of the reaching movement and the degree of rotation of pelvis that accompanies this action. The specific muscle group whose activity is modulated depends of the nature of the task. For example, a backward force disturbing balance in the sitting position elicits activation of upper limb muscles which is amplitude-modulated in school-going children (Van der Fits et al., 1999a, 1999b). In older children, the tendency to modulate activity of more cranially located muscles tends to develop (van der Heide et al., 2003). The ability to modulate EMG amplitude of postural muscles in the standing position develops after the infant becomes capable of standing independently. Between the ages of 2 to 11, it has been shown that the degree to which postural muscles of the lower limbs are activated when balance is disturbed in the standing position decreases with age.

In summary, the second level of posture control is complex and develops over a long period of time and is variable from person to person. In general, the adult level of fine-tuning of posture control is achieved after adolescence.

Postural control in children with CP

Deficits in development of postural control in children are a constant feature in CP. However, very little is known about the exact nature of the deficits. Most of the studies done on children with CP have small sample size and poor design.

There have been very few studies that have studied the development of postural control in infants with CP. One study assessed five infants with spastic hemiplegia and 2 with severe bilateral spastic CP longitudinally from an age of 4 months to 18 months (Hadders-Algra et al., 1999). The study looked at postural control in response reaching movements. The results showed that infants with spastic hemiplegia showed direction specific adjustments from 15 months onwards. However, unlike normally developing infants, they did not develop the ability to adjust EMG-amplitude in response to velocity or pelvis position till the age of 18 months. Among the two infants with bilateral spastic CP, one showed a pattern similar to those with spastic hemiplegia but at a slower pace, and the other had severed disordered development and failed to sit independently even at 4 years of age.

In general, most children with CP eventually develop direction-specific postural activity in sitting as well as standing postures. Mild to moderate difficulties in recruiting direction-specific muscles, especially in the leg muscles, may persist (Van Der Heide et al., 2004; Woollacott et al., 2005). Children with severe CP, who are not able to sit independently, may show a total lack of direction-specific postural adjustments. In contrast, CP children almost always show impairments in fine-tuning postural adjustments. This includes an inability to vary recruitment order, excessive co-activation of antagonistic muscles when balance is disturbed and decreased ability to modulate EMG-amplitude of postural muscles (Carlberg and Hadders-Algra, 2005; Van Der Heide et al., 2004).

Abnormalities in recruitment of postural muscles

Children with CP have a strong tendency to develop a top-down recruitment pattern in posture control. This pattern is more commonly seen in children with mild-to-moderate forms of CP, thus indicating that this may be an adaptive response to deficient posture control (Nashner et al., 1983; Woollacott et al., 1998). It is known that stability of the head is a primary goal of posture control development (Pozzo et al., 1990). Therefore, the top-down recruitment pattern may reflect an adaptive response to maintain head stability (Latash and Anson, 1996; Van Der Heide et al., 2004).

Increased antagonistic co-activation:

Increased co-activation of antagonistic muscles when balance is disturbed (as in perturbation experiments) is a common feature in children with CP (Brogren et al., 1998; Woollacott et al., 2005). In the sitting posture, a backward body sway induces a greater co-activation, compared to a forward sway. Children with CP rarely show antagonistic co-activation during reaching in a sitting position (Van Der Heide et al., 2004).

Impaired modulation of degree of postural muscle contraction:

The inability to modulate the degree of postural muscle contraction is the major postural dysfunction of children with CP (Brogren et al., 2001; Van Der Heide et al., 2004; Woollacott et al., 2005). These children have difficulties in using information of initial body configuration in order to adapt postural activity during activities like reaching for objects while sitting. Children with spastic hemiplegia able to do this to a limited extent, however, those with bilateral spastic CP lack this ability entirely (Van Der Heide et al., 2004).

In summary, children with severe forms of CP, who do not develop the ability to sit independently by the age of 18 months, have serious postural dysfunction even at the first level of posture control, i.e., direction-specific adjustments. Children with milder forms have an intact first level of postural control. However, they have multiple disabilities related to the second level of postural control. This includes: a dominant head-down recruitment pattern, increased co-activation of antagonistic muscles in response to balance perturbations, and most importantly, a reduced or absent ability to modulate the degree of muscle contraction in response to body configuration and velocity of movement.

Therapeutic interventions to improve balance in CP

Balance control is important for performance of most functional skills. Therefore improvement of balance, both static as well as during movement is one of the main goals of therapy in CP. It has been shown in normally developing infants that balance training can hasten development of postural control. Based on these studies, it was hypothesized that such training could be beneficial to children with CP as well. In one study, school-age children with CP were subjected to intense balance training using a moving platform that produced balance threats at irregular intervals (a total of 100 perturbations at 4 to 6 per min for five days) (Shumway-Cook et al., 2003). Balance was evaluated prior to, immediately after and 1 month post training. The results showed an improvement in the ability to recover after balance treats. Improvements were also seen in the total sway rate (Center of Pressure [CoP] movement velocity) and the time required for recovery of balance.

The specific neuromuscular changes that accompany improvements in balance include (Woollacott et al., 2005)

a. Increased bottom-up pattern of postural muscle recruitment (distal muscles contracting before proximal muscles)
b. Decreased time required for recovery of balance
c. Reduced co-activation of agonists and antagonist muscles.

Children with milder forms of CP tended to benefit more from the intervention. In addition, the neuromuscular changes in seen in each child was unique, suggesting that each child developed his/her own unique strategy to cope with his/her disability.

The authors suggest that the possible neural mechanisms underlying changes in neuromuscular response characteristics could include the following:

a. improved proprioceptive sensitivity in leg muscles,
b. increased synaptic efficacy within primary sensorimotor cortex

c. adaptation at the level of cerebellum or association cortex.

The results of these studies suggest that it is indeed possible to improve balance and posture control in children with CP. Additional modalities need to be explored in order to introduce novel therapies that can maximize postural control that these children can attain. Virtual reality gaming is one such approach and is discussed in detail on page 17.

UPPER LIMB AND HAND FUNCTION IN CP

CP is characterized by many types of upper limb and hand disabilities. These include, motor weakness, sensory impairment, spasticity and dystonia. Due to this, they have difficulties in pointing, reaching, holding, releasing and manipulating objects. Upper limb function is critical as it can have major implications on educational achievements, independence in activities of daily living and vocational opportunities.

The typical upper limb deformities in CP include the following (Chin et al., 2005):

a. Shoulder: spasticity and contracture of pectoralis major and subscapularis results in internal rotation and adduction of the shoulder. In some children, this can lead on to anterior subluxation/dislocation of the humeral head.
b. Elbow: spastic biceps, brachialis and brachioradialis can cause flexion deformities of the elbow. This can lead on to a fixed flexion deformity of the elbow over a period of time.

c. Forearm: spasticity of the pronator teres and pronator quadratus causes the forearm to be fixed in pronation. This leads to rotational deformities of the radius and ulna, contracture of the interosseous membrane and subluxation/dislocation of the radial head.
d. Wrist: Flexion deformity of the wrist is common. Ulnar deviation usually accompanies wrist flexion due to the spastic ulnar deviators which are generally more powerful than the radial deviators.
e. Fingers: Flexion deformity of the fingers is also common. The ‘thumb-in-palm’ deformity results from spastic adductor pollicis or flexor pollicis brevis. Since the thumb plays a crucial role in hand function, the deformity of the thumb along with wrist flexion is responsible for the most significant functional impairment (Chin and Graham, 2003; Johnstone et al., 2003; Skoff and Woodbury, 1985).

Hand function:

Hand function is crucial for performance of ADL and therefore rehabilitation of hand function is an important aspect of therapy in CP.

In general, functional activities of the hand can be classified as prehensile and non-prehensile. Prehensile activities of the hand involve the grasping or holding an object between any two surfaces of the hand. The thumb is required for most prehension tasks. Non-prehensile activities typically involve all fingers and both hands, with the exception of pointing and goal-directed aiming movements (Norkin and Levangie, 2005).

Prehension can be of 2 types:

1. Power grip (full hand prehension):

   Power grip is a forceful flexion of all finger joints (clenched fist) in order to hold an object most commonly, the palm. When the thumb is used, it acts as a stabilizer.

2. Precision handling (finger-thumb prehension):

   Precision handling, in contrast, is the skillful placement of an object between fingers or between finger and thumb (like holding a pencil or a pen). The palm is not involved in this activity.

Power grip can be of 4 types (Flatt, 2000):

1. Cylindrical grip: uses only the flexors to maintain the hold on an object.
2. Spherical grip: the thumb, the thenar muscles act in addition to the finger flexors to hold the object. It indicates greater speed and strength in holding the object.
3. Hook grip: primarily involves he fingers only. The fingers are hooked in order to hold the object with minimal help from the palm. The thumb is not involved (e.g., holding a bag with the fingers only).
4. Lateral prehension is a unique form of grasp. The object is held between two adjacent fingers. Contact occurs between two adjacent fingers.

Precision handling can be of 3 types:

1. Pad-to-Pad prehension: opposition of the pad, or pulp, of the thumb to the pad, or pulp, of the finger. About 80% of all precision handling of this type.
2. Tip-to-tip prehension: the tip of the finger is opposed to the tip of the thumb.

3. Pad-to-side prehension: pad of the thumb is opposed to the side of the index finger (holding a key)

Children with CP consistently have abnormalities in hand function. However, the extent of the disability varies from child-to-child based on the severity of the condition. Improvement of hand function, both prehensile and non-prehensile is a major goal of therapy in CP.

Therapeutic modalities to improve upper limb and hand function in CP

A multidisciplinary team consisting of physiatrists, occupational therapists, physiotherapists and orthopaedic surgeons is required for management of upper limb function in CP .

The general principles of management include:

1. reduction of spasticity
2. prevention and correction of deformities
3. strengthening antagonist muscles
4. re-training functional patterns of movement.

The goal of treatment is to improve upper extremity function, facilitate dressing and hygiene, improve cosmetic appearance and reduce the risk of developing fixed contractures.

Therapeutic option for upper limb dysfunction may be surgical or non-surgical. In general, non- surgical techniques are preferred prior to development of contracture. However, surgery is necessary when contractures develop (Chin et al., 2005).

I. Occupational therapy and physiotherapy: These include neurodevelopmental treatment, motor learning, conductive education, strength training and constraint induced movement therapy, splinting and casting
II. Spasticity management: This is divided into focal (phenol neurolysis, botulinum toxin A) or regional management (implantable intrathecal baclofen and selective dorsal rhizotomy)
III. Surgery: This includes soft-tissue (muscle-tendon recession or lengthening, and tendon transfers to restore muscle balance), and bony procedures (corrective osteotomy and joint stabilization)

Treatment goals for individual patients are determined by the severity and extent of CP involvement. Children with spastic hemiplegia often have a large degree of upper limb function and will require interventions aimed at developing more sophisticated fine motor hand control for bimanual hand activities. In addition, cosmetic appearance of the position of the upper limbs is a major treatment goal. Children with spastic quadriplegia will have more severe upper limb spasticity. In such children, improvement of hand activities such as grasping and releasing and assistive walking devices is the main objectives of treatment. These will help in increasing the ease of dressing and hygiene which is a primary reason for improving upper limb function (Chin et al., 2005).

Many children with CP are wheel-chair bound. Special seating in these circumstances has been shown to improve posture control and upper limb function. The ideal sitting position is one that gives the child the best orientation to control the arm and the hand in activities as eating, and dressing. Studies have shown that in children with spastic hemiplegia, the forward tilted position is the optimal sitting condition, whereas in children with bilateral spastic CP, the horizontal sitting position seems to be optimal (Van Der Heide et al., 2004).

VISUO-SPATIAL PERCEPTION IN CP

Gibson defines "visual perception as the process by which we obtain firsthand information about the world around us". Perceptual learning refers to an increase in the ability to extract information from the surrounding environment. The development of visual perception begins from birth with the reception of visual stimuli, followed by orientation of the head and eyes and the identification and integration of dominant visual cues (Menken et al., 1987).

The ability to perceptually analyze and discriminate objects shows a systematic increase in the developing child. The most immediate form of perceptual response for children between 5 to 11 years of age is the response to a whole figure rather than the details of a figure which is later acquired. Figure-ground perception (the ability to perceive a form visually and to find this form hidden in a conglomerated background) develops from 3 to 5 years and is stabilized at 6 to 7 years. Form constancy (the ability to see a form, and be able to identify it, even though it may be smaller, larger, rotated, reversed, or hidden) development shows steep increase from 6 to 7 years of age and is stabilized at 8 to 9 years. Position in space is developed around 7 years of age and spatial relationships by 10 years of age. If we consider visual-perceptual development by age levels, it usually takes 9 years for the maturation of specific visual-perceptual skills (Menken et al., 1987).

People with cerebral palsy frequently have visual perceptual deficits. These are related to many areas of function in children with CP. They often have reading difficulties due to concomitant visual skill deficits. They also tend to have slower rates of visual imagery processing (Kozeis et al., 2007; Stiers et al., 2002)

VIRTUAL REALITY GAMES IN CP

Virtual reality has been defined as the use of interactive simulations created with computer hardware and software to present users with opportunities to perform in virtual environments that appear, sound, and feel similar to real-world objects and events. Interactive computer play is defined as ‘‘any kind of computer game or virtual reality technique where the child can interact and play with virtual objects in a computer-generated environment using a variety of interface devices such as a mouse, keyboard, or head mounted display”.

The simplest form of virtual reality is a 3-D image that can be explored interactively at a personal computer, usually by manipulating keys or the mouse so that the content of the image moves in some direction or zooms in or out. More sophisticated efforts involve such approaches as wrap-around display screens, actual rooms augmented with wearable computers, and haptic devices that let you feel the display images.

There are several advantages of using virtual reality in pediatric rehabilitation. They provide opportunities for active learning which are motivating and enjoyable, yet challenging and safe. It is essential that the skills acquired by use of virtual reality intervention should be transferred to the ‘‘real world’’ which would determine its effectiveness. In a pre–post intervention study of young children with cerebral palsy, increased playfulness, as assessed with the Test of Playfulness was achieved via virtual reality play using the Sony PlayStation 2 EyeToy. A randomized controlled trial on 31 children with cerebral palsy did not show significant evidence of a positive treatment effect due to virtual reality (Reid and Campbell, 2006) but a smaller randomized controlled trial (n = 10), using the EyeToy, did show treatment effects in terms of improvement in arm kinematics (Jannink et al., 2008). Jelsma et al (Jelsma et al., 2013) showed benefits from training on the Nintendo Wii Fit on clinical measures of balance control for children with spastic hemiplegic cerebral palsy although these effects did not translate into functional improvement.

To determine whether virtual reality interventions also have a long-term effect, Chen et al (Chen et al., 2007) investigated the training effects of a virtual reality intervention on upper limb reaching. Four young children with spastic cerebral palsy used Sony PlayStation 2 EyeToy as well as a sensor glove to practice grasping activities. Three of the 4 children showed some improvement in the quality of reaching performance, showing the ability of a simple off-the-shelf virtual reality system to improve motor control.

Virtual reality games offer several advantages. In addition to the dynamic nature of stimulus delivery, they also enable the therapist to grade the level of cognitive and/or motor demands placed on the child. By varying task complexity, feedback, and extent of independent activity, the clinician can closely monitor the response of these children. The most significant aspect to virtual reality gaming is the fact that it provides the children with the motivation to perform multiple task-oriented repetitions. This is especially important for children who are not compliant in following the conventional exercise program as the exercises are less meaningful and interesting.

Many individuals with cerebral palsy have a sedentary lifestyle. This puts them at risk for cardiovascular disease, obesity, and musculoskeletal problems (Maher et al., 2007; Rimmer, 2001). Therefore, virtual reality games provide exercise by promoting physical activity and enhanced cardiovascular fitness while engaging in activities that are fun. Customized systems which are designed specifically for the needs of individuals with cerebral palsy are also used in several cases.

Virtual Reality games as a mode of improving balance and posture control

There have been a few studies that have looked at virtual reality games in improving balance and postural control. They are summarized in Table 1:

Table 1: Studies that have looked at virtual reality games in improving posture control and balance

Sl no.	Study	Characteristics	Design	Brief results
1	Brutsch et al. (Brütsch et al., 2010)	*Sample size*: With gait disorder: n = 10 Controls: n = 8 *Gender* : With gait disorder: 4 males, 6 females Controls: 2 males, 6 females *Mean age*: With gait disorder: 14.2 years Controls: 11.8 years	*Design:* Within groups (2 groups) *VR system:* Lokomat system *Intervention:* Robotic Assisted Gait Training and/or VR *Treatment intensity:* 1 session, 4 conditions ×2 min	Increased motor output with instructor encouragement and VR, both separately and in combination, for all children in both groups
2	Bryanton et al. (Bryanton et al., 2006)	*Sample size* : With CP: n = 10 Without CP: n = 6 *Gender* With CP: 4 males, 6 females Without CP: 2 males, 4 females	*Design:* Within subjects (AB-BA design) *VR system:* IREX system *Intervention:* Conventional and VR exercises to improve ankle dorsiflexion *Treatment intensity:* 1× 90-min session	*Average hold times*: all children showed longer hold times in the VR exercises *Mean ankle range of motion into dorsiflexion*: all children achieved significantly greater range of motion during the VR exercises than during Conventional exercises

3	Deutsch et al. (Deutsch et al., 2008)	Sample size: 1 Gender: male Age: 13 years	*Design:* Single case study *VR system:* Nintendo Wii system *Intervention:* Wii games to improve visual perception, posture and functional mobility *Treatment intensity:* 11× 60–90 min, over 4 weeks	Test of Visual Perceptual Skills, ed 3 (TPVS-3): improvements in all domains except visual memory Postural Scale Analyzer: center-ofpressure sway decreased, increased symmetry of weight distribution Functional mobility (ambulation with forearm crutches): great improvements in distance of independent ambulation
4	Kott et al. (Kott et al., 2009)	Sample size n = 5 Gender All male Mean age: 7.5 years	*Design:* Within group *VR system:* Desktop system with treadmill *Intervention:* Treadmill therapy to increase functional mobility *Treatment intensity:* 9 h, in 10–12 sessions, over 3–4 weeks	Significantly increased speed for walking GMFM-88 dimension E: significant increase in percentage of items accomplished Treadmill speed: significant increase in speed from initial to final session
5	Reid (D. Reid, 2002)	Sample size: VR group: n = 3 Control: n = 3 Age range 9–12 years	*Design:* Between groups *VR system:* IREX system *Intervention:* Exercises focused on upper extremity and trunk control *Treatment intensity:* 2× 90-min, 4 weeks	improvements in VR group in posture measures during rest and reaching

6	Brutsch K (Brütsch et al., 2011)	Sample size: VR group: n = 10 Control: n = 14 Age mean: 12 years	*Design:* Between groups *VR system:* Lokomat *Intervention:* Gait training	Virtual reality-assisted therapy approaches were effective in initiating the desired active participation in all children, compared with conventional training conditions.
7	Brien M (Brien and Sveistrup, 2011)	Sample size: 4 Age : adolescents	*Design:* Single-subject, multiple-baseline design *VR system:* Customized *Intervention:* Daily 90-minute VR intervention was completed for 5 consecutive days	Functional balance and mobility improved, and changes are maintained at 1-month post-training.
8	Gordon C (Gordon et al., 2012a)	Sample size: 7 Age: 6- 12 years	*Design:* Pilot study of feasibility, pre and post test *VR system:* Nintendo Wii *Intervention:* 45 min, twice weekly for 6 weeks	Mean GMFM score increased from 62.83 (SD 24.86] to 70.17 (SD 23.67).
9	Luna-Oliva L (Luna-Oliva et al., 2013)	Sample size = 11 Age: adolescents	*Design:* Pilot study pre-post and follow-up testing *VR system:* X-box 360 Kinect *Intervention:* 8 weeks	Improvements in balance and ADL in a school environment

Most of the studies described above show that virtual reality gaming tended to improve balance and posture control. However, all the studies have small sample size and have been designed as feasibility studies or pilot studies. In addition, comparisons between studies are difficult due to the differences in the type of virtual reality game chosen and the intensity and duration of the intervention.

Virtual Reality games as a mode of improving upper limb and hand function

The available literature on use of virtual reality games in improving upper limb and hand function are summarized below in

Table 2: Studies that have looked at virtual reality games in improving upper limb and hand function

Sl no.	Study	Characteristics	Design	Brief results
1	Chen et al. (Chen et al., 2007)	Sample size n = 4 Gender3 males, 1 females Mean age 6.3 years	*Design:* Single subject (A-B with follow-up) *VR system:* Desktop display with integrated sensor glove and Sony EyeToy system *Intervention:* VR-based hand rehabilitation training system and Sony EyeToy to improve reaching behaviors *Treatment intensity:* 120 min per week, 2–3 sessions per week for 4 weeks	Reaching kinematics (Mail delivery task): variable improvements in all children on task in neutral, outward and inward directions Fine Motor Domain of Peabody Developmental Motor Scales – Second Edition (PDMS-2): All children showed increases in total score on grasping and visuo-motor tasks. Most of the increase was attributed to the increase on visuomotor tasks

2	Fluet et al. (Fluet et al., 2009)	*Sample size* Group one: n = 4 Group two: n = 4 *Gender* Group one: 3 males, 1 female Group two: 1 male, 3 females *Age range* Group one: 7–16 years Group two: 5–12 years	*Design:* Within groups, 2 groups *VR System:* HapticMaster with robotics *Intervention:* 5 haptic games to improve speed and accuracy of shoulder and elbow movements *Treatment intensity:* Group one: 3× 60-min per week, 3 weeks Group two: 3× 60-min per week, 3 weeks; additional 6 h of other treatment	Reaching kinematics on bubble explosion: all subjects improved on measures of duration, smoothness and path length of reaching kinematics. Improvements were greater for Group Two subjects Melbourne Assessment of Unilateral Upper Limb Function (MAUULF): mean scores of Group one improved significantly. Mean scores of Group two improved , but not significantly. Combined scores from both groups indicated significant gains
3	Huber et al. (Huber et al., 2008)	*Sample size* n = 3 *Age* Teenagers	*Design:* Within subjects *VR System:* Playstation system with 5DT Ultra glove *Intervention:* Home telerehabilitation system with finger range of motion and finger velocity games to improve hand function *Treatment intensity:* 30 min per day, 3 months	Activities of Daily Living: improved significanty. Jebson Test of Hand Function: significant improvements seen Bruininks-Osertsky Test: notable improvements in one child

5	Li et al. (Li et al., 2009)	Sample size n = 5 Gender 4 males, 1 female Mean age 8.1 years	*Design:* Within groups *VR system:* Sony EyeToy system *Intervention:* Two EyeToy games chosen to improve gross elbow and shoulder motion *Treatment intensity:* 10× 30-min sessions	Elicitation of target UE movements: all children performed all target movements Number of exercise repetitions: children performed an average of 13 movements per minute Playing time: children played an average of 19 min per session
6	Jannick et al. (Jannink et al., 2008)	*Sample size* Experimental: n = 5 Control: n = 5 *Gender* 9 males, 1 female *Age range* 7–16 years	*Design:* Between groups (two groups) *VR system:* Sony EyeToy system *Intervention:* Three EyeToy games chosen to improve gross elbow and shoulder motion *Treatment intensity:* 2× 30-min per week, 6 weeks	Melbourne Assessment of Unilateral Upper Limb Function (MAUULF): Control group: 4 with zero or negligible changes, 1 with notable improvement; Experimental group: 3 with zero or negligible changes, 2 with considerable improvement
7	Odle et al. (Odle et al., 2009)	*Sample size: n = 3* *Gender*: All male *Age*: 4, 10 and 12 years	*Design*: Within subjects *VR system*: Hands-Up System *Intervention*: Customized games to improve upper extremity movement *Treatment intensity*: 1× 60-min per week, 5 weeks	All three children improved in motor tasks that were given before and after the intervention

8	Reid (D. T. Reid, 2002)	*Sample size* n = 4 *Age range* 8–12 years	*Design:* Single case study *VR system:* IREX system *Intervention:* Games to promote upper extremity range of motion, mobility and strength *Treatment intensity:* 1× 90-min session per week, 8 weeks	Quality of Upper Extremity Skills Test (QUEST): 2 of 4 children showed clinically significant improvements Bruininks-Oseretsky Test of Motor Proficiency (BOTMP): subtest #5, item #6: All children showed improvements Orbosity program: percent accuracy: 2 of 4children showed notable improvements
9	You et al. (You et al., 2005)	Sample size n = 1 Male 8 years	*Design:* Single case study *VR system:* IREX system *Intervention:* Games to promote upper extremity range of motion, mobility and strength *Treatment intensity:* 5× 60-min per week, 4 weeks	Bruininks-Oseretsky Test of Motor Proficiency subtest #5, item #6 (BOTMP): considerable improvements Modified Pediatric Motor Activity Log (PMAL): considerable improvements Fugl-Meyer Assessment (FMA): considerable Improvements fMRI: no observable or meaningful changes in regions of interest

10	Winkels DG(Winkels et al., 2013)	Sample size = 15	*Design:* Within group – pre and post intervention testing *VR system:* Nintendo Wii *Intervention:* Games to promote upper extremity range of motion, mobility and strength *Treatment intensity:* 6 weeks	quality of upper extremity movements did not change (-2.1, $p > 0.05$)/ Significant increase of convenience in using hands/arms during performance of daily activities was found (0.6, $p < 0.05$).
11	Rostami HR (Rostami et al., 2012)	Sample size: 32 Gender: 18 female, 14 male	*Design:* single-blinded, randomised, controlled trial *Intervention:* 3 different groups (virtual reality, modified constraint-induced movement therapy, and a combination group *Treatment intensity:* 90 min sessions, 3 times per week for 4 weeks	Significantly higher gains were observed in the combination therapy group for the amount of limb use (mean change, 2.72), quality of movement (mean change, 2.79), and speed and dexterity (mean change, 1.74) at post-test. These gains were maintained at the 3-month follow-up assessment.
12	Sandlund M (Sandlund et al., 2014)	Sample size n = 15	*Design:* Within group *Intervention:* 4 weeks of home-based training with motion interactive video games	Improved arm motor control in children with CP

There were more number of studies that assessed upper limb function in CP compared to posture control and balance (12 vs 9). However, most of these studies were small and have been designed as feasibility studies or pilot studies. Only one study was a randomized control trial (Rostami et al., 2012).

NINTENDO WII™

Nintendo Wii™ (Wii) is one of the most popular home-based gaming consoles available commercially. It consists of a wireless hand-held pointing device (the Wii remote), the movement and acceleration of which is detected in 3-dimensions by a motion-sensor attached to a television. The user sees a virtual image of himself/herself on the television screen that mimics his/her movements. The games are interactive and encourage the user to play repetitively. The wireless nature of the Wii remote, as well and the haptic feedback it affords, are unique features of the Wii.

The Wii has been successfully used in the rehabilitation of post-stroke patients (Saposnik et al., 2011, 2010).

In 2008, Deutsch et al. 2008 (Deutsch et al., 2008), published a case report in which Wii was used in rehabilitation of a 13-years-old child with spastic diplegic cerebral palsy. They reported improved posture control, visual-perceptual skills, and mobility. At the time of initiation of this study, no additional studies were published to provide further evidence on the possible beneficial role of Wii in improving posture control in children with CP. However, over the past 2 years there have been a few publications that have evaluated the use of Wii in rehabilitation of children with cerebral palsy. These have been summarized in Table 3.

Table 3: Studies that have looked at Nintendo Wii in rehabilitation of children with CP

Sl no.	Study	Characteristics	Design	Brief results
1	Gordon C (Gordon et al., 2012a)	Sample size: 7 Age: 6- 12 years	*Design:* Pilot study of feasibility, pre and post test *Intervention:* 45 min, twice weekly for 6 weeks	The GMFM score was used to measure motor function. The mean GMFM score increased from 62.83 (SD 24.86] to 70.17 (SD 23.67).
2	Winkels DG(Winkels et al., 2013)	Sample size = 15	*Design:* Within group – pre and post intervention testing *Intervention:* Games to promote upper extremity range of motion, mobility and strength *Treatment intensity:* 6 weeks	Quality of upper extremity movements did not change (-2.1, $p > 0.05$) Significant increase of convenience in using hands/arms during performance of daily activities was found (0.6, $p < 0.05$).
3	Jelsma J (Jelsma et al., 2013)	Sample size: 14	*Design:* Within group- pre and post intervention testing *Intervention:* Nintendo Wii Fit instead of regular physiotherapy *Treatment intensity:* 3 weeks	Bruininks-Oserestky test of Motor Performance 2 and the timed up and down stairs (TUDS) were used for assessment. Balances score improved significantly. Changes over time in the running speed and agility were not significant.
4	Ramstrand N (Ramstrand and Lygnegård, 2012)	Sample size: 18	*Design:* randomised cross-over design *Intervention:* Nintendo Wii Fit instead of regular physiotherapy *Treatment intensity:* 30 minutes per day for 5 week at home	Outcome measures of interest included: performance on the modified sensory organisation test, reactive balance test and rhythmic weight shift test. No significant difference was observed between testing occasions for any of the balance measures investigated ($p > 0.05$).
5	Tarakci D (Tarakci et al., 2013)	Sample size : 14 11 males, 3 females; mean age 12.07 ± 3.36 years)	*Design:* With group – pre and post intervention testing *Intervention:* Nintendo Wii Fit instead of regular physiotherapy *Treatment intensity:* 2 times a week for 12 weeks	Balance functions before and after treatment were evaluated using one leg standing, the functional reach test, the timed up and go test, and the 6-minute walking test. Balance ability of every patient improved. Statistically significant improvements were found in all outcome measures after 12 weeks.

The few studies described above that have looked at the utility of Wii in children with CP have been done over the last 2 years after the current study was initiated. All of these studies have small sample sizes and have been designed as within-subject trials with pre and post-intervention testing to assess effectiveness of the intervention. In most of these studies VR therapy was provided without routine physiotherapy. Due to this, although the results obtained show improvements, no information is available on whether these improvements are significantly better than those obtained by routine physiotherapy alone. Therefore this study, which is designed as a pilot, randomized controlled trial to assess the clinical utility of Wii along with routine physiotherapy compared to a group receiving only routine physiotherapy, addresses an important gap in knowledge in this field.

Methodology

METHODOLOGY

DESCRIPTION OF THE STUDY:

The objective of the study was to observe the effect of Nintendo Wii games on the balance of children with CP. This study was done as a pilot randomized controlled trial with 20 CP children- 10 each in the intervention group as well as the control group. The CP children in control group received regular, conventional, standard therapy to improve motor performance and cognitive skills in the department of PMR, CMC, Vellore. The CP children in the intervention group received routine therapy but also played virtual reality games (as described below) during a time slot within their daily therapy session.

The intervention:

- Type of intervention : Virtual reality gaming using the Nintendo Wii™ gaming console
- Type of games : Boxing and tennis in standing/sitting posture
- Duration : 45-60 minutes per day, 6 days a week, for 3 weeks (18 sessions)

These are described in detail below.

Study participants:

The CP children recruited for the study were among those undergoing rehabilitation therapies to improve motor performance and cognitive skills in the department of PMR.

Inclusion Criteria:

Children with cerebral palsy aged 3 to 20 years who have:

1. adequate functional hand skills to be able to hold the Wii remotes [as assessed by clinical examination].
2. adequate gross motor skills to play in standing/ sitting position for at least 25 minutes at a stretch with or without support and be able to stand for 1 minute with or without aids (but no external support) [as assessed by clinical examination].
3. sufficient cognitive skills to follow directions, stay on task, and understand the games [as assessed by the Paediatric Occupational Therapy (OT) screening test].

Exclusion Criteria:

1. Children who do not meet the above mentioned inclusion criteria.
2. Children with a history of serious and persisting health problems (e.g., congenital heart disease etc).
3. Children who have previously used Wii or other VR-based gaming consoles on a regular basis up to one month prior to recruitment to the study.

The participants in the study were classified into different functional groups according to the Gross Motor Function Classification System (GMFCS).

Target sample size and rationale:

This study had 10 CP children in the intervention group and 10 CP children in the control group.

Rationale for sample size calculation:

Information that was available in the literature on the use of VR gaming in CP at the time of designing this study was mainly limited to case reports and small observational studies. In addition, a wide variety of outcome measures had been used by various investigators. However, posture control/ balance had not been assessed systematically previously. This present study was designed based on a case report by Deutsch et al. (2008) which demonstrated the feasibility and potential for use of Wii gaming console in improving posture control in children with CP. Hence this study was done as a pilot study to assess the use of Nintendo Wii in improving balance in CP children.

All assessment measures of primary and secondary outcomes were done within 1-3 days prior to start of the gaming sessions (pre-intervention analysis) and repeated within 1-3 days after the completion of the gaming sessions (post-intervention analysis).

Method of randomization:

Randomization was done by a faculty member in the department of PMR who was not directly associated with this study. Simple random sampling was done using sequentially numbered envelopes with the sequence generated from an online source. The randomization sequence was obtained from the website: www.random.org.

Method of allocation concealment:

Sequentially numbered, sealed, opaque envelopes

Blinding and masking:

Single blinded- Outcome Assessor Blinded

INTERVENTION:

The CP children who were in the intervention group received Nintendo Wii games for 45-60 minutes per day, 6 days a week for 3 weeks.

Nintendo Wii™

Nintendo Wii™ (Wii) is a commercially available home gaming console marketed by the Japanese multinational corporation, Nintendo. The Wii was released in 2006 and is the best-selling gaming console world-wide. The Wii has many unique features. One of these is the hand-held remote controller called the Wii Remote. The movements of the Wii Remote can be detected in three dimensions by a sensor attached to a television. Wii creates a virtual illusion of the player on the television screen. The player holds the Wii Remote in his/her hand and the movements of the hand holding the Wii Remote is translated into movements of the player's avatar in a virtual play arena. The Wii Remote also provides haptic feedback. For example, the remote vibrates when the ball connects with the racquet in a game of tennis.

Figure 1: Nintendo Wii gaming console (Source: www.gengame.net)

There are 5 games available on a compact disc (CD) that is provided by the manufacturer along with the gaming console on purchase. These include tennis, boxing, bowling, baseball and golf. Additional games may be purchased. In this study, the recruited children were allowed to play tennis and boxing. These games were chosen because these are popular sports and it is assumed that the children will be familiar with these games. On the other hand, bowling, golf and baseball are not popular sports in our country and may not interest the children.

The children in the intervention group were allowed to play Nintendo Wii games- Tennis and Boxing for 20-25 minutes each with a 5 min break in between both the games.

Tennis games:

This was played in the sitting or standing posture for 20-25 minutes.

General description:

Tennis matches are double games. A game player can play against an opponent or the computer. He or she is able to control both the players in the team by holding the remote with one or both hands like a racket. This could be played as a single game, best of three or best of five. The player is placed in the correct spot by the computer to hit the ball. The game player is responsible for the type of swing, angle, timing and the speed with which the player contacts the ball on the screen. The player hits the ball back and forth till he or the opponent misses it.

Therapeutic goals:

It helps to improve trunk control and rotation, eye- hand coordination and attention.

Feedback:

Knowledge of results: The game player receives auditory and haptic feedback while hitting the ball and visual and auditory feedback as an instant replay of the point after each point is won.

Figure 2: Nintendo Wii virtual tennis game

Figure 3: Child playing the Nintendo Wii virtual tennis game

Boxing game:

This was played in the sitting/ standing posture for 20 to 25 min.

General description:

The game player can play the boxing matches against an opponent or a computer. The matches are terminated after a knock out or at the end of three rounds. The Wii remote is connected to a nunchuk controller (the attachment bundled with the Wii console) with one held in each hand. The player while holding the remote punches and blocks the opponent`s punches to fight against the opponent on the screen. The player has the opportunity to get up after being knocked down within ten counts. The person is considered to be knocked out after a certain number of knock downs and the match is over.

Therapeutic goals:

Maintain an erect midline posture while performing a bilateral upper extremity task with change in center of mass. Improve attention, core stability and upper extremity coordination.

Feedback:

Knowledge of results: A pie chart displays the player`s and opponent`s power level which helps in visual feedback. When the player or opponent is hit, the pie-chart decreases in pieces. Haptic feedback is provided when opponent is hit.

Figure 4: Nintendo Wii virtual boxing game

Figure 5: Child playing the virtual boxing game

PRIMARY OUTCOME MEASURES:

A. Static posturography to measure sway velocity:

Sway velocity is the distance travelled by the center of pressure (CoP) per unit time when a person is static in a given posture. It was measured using a force plate and platform at the Gait lab, Department of PMR, CMC, Bagayam, Vellore. This system provides reliable data on sway velocity (movement of center of gravity). It is a computerized devise that allows the real-time assessment of a child's ability to maintain posture control in the standing position. It consists of a force platform linked to a computer to monitor movement of the CoP. The child was asked to stand on the force plate for 8 seconds with orthosis and aids as required. The aids used, e.g., walker or elbow crutches, would be placed outside the force plate. The computer detects the position of the CoP in terms of the x and y coordinates. While the patient stands on the force platform, a reading is recorded every 1/110th of a second. Therefore 880 readings (in terms of x and y coordinates of the CoP) are obtained during a single recording of 8 seconds. The readings obtained during the first two seconds (when the child is stabilizing himself/herself on the force platform) are ignored. Similarly, reading obtained during the last second when fatigue starts to set in is also ignored. The readings obtained from the 3rd to 7th second (total of 5 seconds) are taken into consideration for calculation of the sway velocity. As far as was possible, three recordings with eyes open and with eyes closed were obtained. The best of these three recording was used for calculation. The sway velocity was calculated by calculating the distance travelled by the CoP while the child stands on the force platform per second. Good posture stability is considered to be the relative absence of sway or low sway velocity. Therefore, a reduction in the sway velocity is indicative of an improvement of child`s balance.

Figure 6: Child on the force plate for static posturography

B. The Pediatric Berg's Balance Scale:

The Pediatric Berg's Balance Scale helps in measurement of balance by assessing performance in functional tasks. It is a valid instrument for evaluation of effectiveness of interventions in children with cerebral palsy. It consists of a 14-item scale initially developed for assessment of balance in the elderly and neurologically impaired individuals in a clinical setting. It was later validated in children with CP who have postural abnormalities. Each item would be scored within a range of 0 to 4. The child was given a practice trial on each item whenever required. Hence the child can get a maximum score of 56 and minimum of 0. Multiple trials were allowed and the score for the best performance was noted.

The 14 items tested were:

a. Sitting to standing

b. Standing to sitting

c. Transfers

d. Standing unsupported

e. Sitting unsupported

f. Standing with eyes closed

g. Standing with feet together

h. Standing with one foot in front

i. Standing on one foot

j. Turning 360 degrees

k. Turning to look behind

l. Retrieving object from floor

m. Placing alternate foot on stool

n. Reaching forward with outstretched arm

Details of the scoring methodology are given in the Appendix 3

SECONDARY OUTCOME MEASURES

A. **Upper limb and hand function:**

a. Box and block test:

The Box and Block Test (BBT) assesses unilateral gross manual dexterity. It is a quick, simple and inexpensive test. Fifteen second trial period is allowed prior to testing. The child is asked to grasp one block at a time with the dominant hand, carry the block over the partition, and release it into the opposite compartment. If the child picks up more than one block, it would be counted as only one block. If the child drops a block on the table or floor after he/she has carried it across, it would still be counted. The time allotted is 1 minute and the same test is repeated in the non-dominant hand.

Figure 7: Box and block test

b. Quality of Upper Extremity Skills Test (QUEST):

Recent studies have shown that the Quality of Upper Extremity Skills Test (QUEST) is a reliable measure of gross motor function in the upper limbs in children with cerebral palsy. Since, the intervention (Nintendo Wii games) is likely to significantly improve upper limb functions QUEST was included as one of the secondary outcome measures in this study. This measure assesses mainly four domains of upper extremity function: dissociated movement, grasp, protective extension and weight bearing. For this particular study we have chosen measurement of 2 domains - dissociated movement and grasp.

1. Dissociated movement:

a. Shoulder : The child was asked to do shoulder flexion and abduction keeping elbow, wrist and fingers as per the criteria mentioned in the instructions.
b. Elbow : The child was asked to do elbow flexion and extension keeping elbow and forearm as per the criteria mentioned.
c. Wrist : The child was asked to do wrist flexion, extension keeping elbow keeping forearm, elbow as per the criteria mentioned.
d. Finger :
    i. Independent finger wiggling: The child was asked to do independent finger wiggling without associated reactions or dissociated of all fingers
    ii. Independent thumb movement: The child was asked to do independent thumb movement without associated reactions.
    iii. Grasp of 1 inch cube: The child was asked to grasp a 1 inch cube using a thumb keeping shoulder, elbow and wrist as per the criteria mentioned. If the child

was unable to do so, then he/she will be asked to grasp using palm with the same criteria.

iv. Release of 1 inch cube: The child was asked to release a 1 inch cube using a thumb keeping shoulder, elbow and wrist as per the criteria mentioned. If the child was unable to do so, then he/she will be asked to grasp using palm with the same criteria.

2. Grasps:

Child`s sitting posture (head, trunk and shoulder) while doing grasps was observed. Scores are given depending on whether normal or atypical postures were adopted.

a. Grasp of 1 inch cube: The child is asked to grasp a 1 inch cube in radial digital position keeping wrist as per the criteria mentioned. If the child is unable to do so, then he/she will be asked to grasp in radial palmar position with the same criteria. If he/she is unable to do so the child should be asked to do the grasp in palmar position with the same criteria.
b. Grasp of cereal: The child is asked to hold a cereal with 2 fingers keeping the wrist in neutral to extension. The score given will be different according to the type of grasp from highest to lowest in the order fine pincer, pincer, inferior pincer, scissor and inferior scissor.
c. Grasp of crayon or thumb: The child is asked to hold a pencil or crayon. The score given will be different according to the type of grasp from highest to lowest in the order dynamic tripod, static tripod, digital pronate and palmar supinate.

Details of the test and scoring methodology are given in Appendix 4

Figure 8: Grasp of pencil as part of QUEST assessment

Figure 9: Grasp of 1 inch cube as part of QUEST assessment

B. Test for Visual-Perceptual Skills, 3rd edition (TVPS-3).

The TVPS-3 is a non-motor assessment of visual perceptual skills in children aged 4 to 18 years whose reliability in cerebral palsy has been validated. It is designed for both diagnostic and research purposes. The TVPS-3 utilizes 112 black and white designs. This test includes 7 sub-tests that are designed to assess integration of visual perception and action. The tests are arranged in order of difficulty. Visual discrimination which is the first test requires only very basic skill whereas the last test visual closure is a much more difficult task. Among the subsets only visual memory and sequential memory are timed components in which the child was shown the figure only for 5 seconds. The time for administration was approximately 30 minutes. However in situations where the child had a short attention span, the test was done in multiple sittings with extended time periods. Each of the seven subtests start with 2 example items (not scored). It is followed by 16 test items of increasing difficulty. However in this study we administered only 10 test items for all the children as most of them were not able to co-operate for all the 16 items.

The TVPS-3 has a multiple choice format. The child can indicate an answer choice verbally or by pointing the correct answer or by some other agreed-upon method of communication. The child was allowed to guess if he/she does not know the answer.

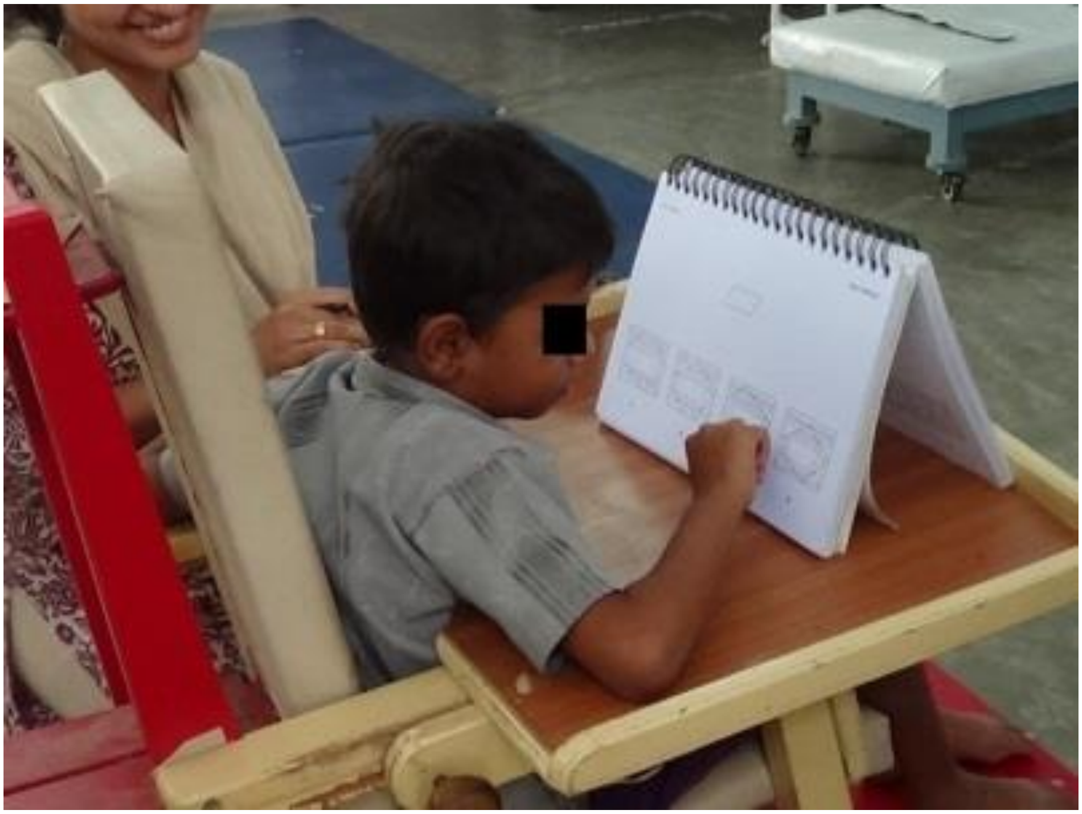


Figure 10: Child undergoing the TVPS test

The 7 subtests include:

1. ***Visual discrimination:*** the child was shown a design and asked to find the matching design among the choices shown below
2. ***Visual memory:*** the child was shown (for 5 seconds) a design on one page. The page was then turned and the child was asked to find the same design from among the choices shown on the next page
3. ***Spatial relationship:*** the child was shown a series of designs on a page. He/she was then asked to choose the one that was different from the rest. The difference could be in a detail or in the rotation of all or some part of the design.

4. ***Form consistency***: the child was asked to find one design among others on the page; the design can be smaller, larger or rotated.
5. ***Visual sequential memory:*** the child was shown (for 5 seconds) design sequences. Following which the page was turned and the child was asked to find the matching design from among the choices on the following page.
6. ***Visual figure-ground:*** the child was asked to find a specified design among many within a complex background.
7. ***Visual closure***: the child was shown a completed design on a page and was then asked to match it to one of the incomplete patterns shown on the same page.

Details of the test and scoring methodology are given in the Appendix 5

C. Functional ambulation:

Functional ambulation was assessed by walking speed and distance (endurance) measurements.

The maximum distance the child was able to walk at a stretch without a rest period was measured. The speed of walking was calculated by instructing the child to walk for one minute with the self-selected walking speed. The distance covered during that time will be taken as the speed (metres/ min). Child`s pre and post intervention measurements were done with the same set of orthosis and aids. For walking endurance, the child was asked to walk at a self-selected speed without a break for as long as possible, The total distance covered in meters was documented. In all cases, the child was allowed to use lower limb orthosis and aids as required.

STATISTICAL ANALYSIS:

Statistical analysis was done using the Statistical Package for the Social Sciences (SPSS) version 16.0. As the sample size in each group was small, non-parametric tests were used to estimate statistically significant differences. The Mann Whitney test was used to look at significant differences between the two groups at baseline and after the intervention. The Wilcoxon signed-rank test was used to look for significant differences before (pre-test) and after (post-test) the intervention within each group. In order to look for significant differences between the changes seen in the control and intervention group, a Mann-Whitney test was done on the post minus pre-test scores for the control and intervention group. A p-value < 0.05 was used to indicate statistically significance.

The above outcome measures were analyzed in both the intervention as well as the control group of children with CP. The results are as follows.

Results

RESULTS:

The primary aim of the study was to assess the effect of Nintendo Wii virtual reality gaming on the postural control and balance of children with CP. The secondary outcomes measured were upper limb and hand function, visual perception and functional mobility. A total of 20 CP children were included in the study - 10 in the intervention group and 10 in the control group. The basic demographic details are given in Table 4. There were, in total, 11 boys and 9 girls, with 5 boys and 5 girls in the control group and 6 boys and 4 girls in the intervention group. There were 2 drop outs - one each in the control group and intervention group. The mean age of the children was 12.4 years (range 4 to 18 years) in the control group and 10.6 years (range 6 to 18 years) in the intervention group. There were no significant differences in the ages of children recruited in each arm of the study ($p = 0.446$).

As detailed in the methodology section, each subject was assessed at baseline (pre-test) and after the intervention (post-test). Sway velocity measured by static posturography and Pediatric Berg's Balance Scale were used to assess the posture control (primary outcome). Secondary outcomes assessed were Box and Block test and QUEST (Quality of Upper Extremity Skills Test), TVPS (Test for Visual Perceptual Skills) and walking speed and endurance (functional ambulation). For each parameter, comparisons were first made between the pre-test values in the control and intervention groups to look for the effectiveness of randomization. Further analysis was done only if pre-test values were not significantly different between the two groups. Following this, post-test and pre-test values in the control and intervention groups were compared using the Wilcoxon signed-rank test (non-parametric equivalent for paired t-test). Finally, the difference in values obtained in post and pre-test for each subject was calculated. Significant differences between these values obtained for intervention group compared to control group was assessed. This was done in order to look for statistically significant differences between changes seen in the intervention group compared to changes in the control group.

Table 4: Demographic details of the study population

	Patient code	Age	Gender	Diagnosis	GMFCS at recruitment	Aids used	Posture while playing
CONTROL GROUP	**C1**	11	M	Spastic diplegia	1	No aids	-
	C2	16	F	Spastic diplegia	3	Bilateral KAFO, reverse walker	-
	C3	10	F	Spastic diplegia	3	Reciprocal reverse walker, bilateral AFO, gaiters	-
	C4	18	F	Spastic diplegia	2	Bilateral AFO, Right EC	-
	C5	18	F	Spastic quadriplegia	3	Walker, bilateral AFO.	-
	C6	4	M	Spastic diplegia	3	Bilateral AFO, gaiters, walker.	-
	C7	17	F	Spastic quadriplegia	4	Bilateral AFO, 2 person support	-
	C8	13	M	Spastic triplegia	3	Bilateral AFO, dynamic knee brace, walker	-
	C9 *	6	M	Spastic diplegia	3	Bilateral AFO, bilateral elbow crutches.	-
	C10	11	M	Spastic diplegia	2	No aids	-
INTERVENTION GROUP	**T1**	6	M	Spastic diplegia	3	Bilateral AFO, gaiters & reciprocal walker.	Sitting
	T2	6	M	Spastic triplegia	3	Bilateral AFO, gaiters	Standing
	T3	18	M	Spastic triplegia	3	Left AFO	Standing
	T4	9	F	Spastic diplegia	3	Walker, bilateral AFO	Standing
	T5	14	F	Spastic triplegia	3	Walker, bilateral KAFO	Standing
	T6	12	F	Spastic triplegia	4	Bilateral KAFO, bilateral elbow crutches, one person max. support	Standing
	T7	11	M	Spastic diplegia	2	No aids	Sitting
	T8	12	M	Spastic diplegia	3	Bilateral AFO, gaiters, reverse reciprocal walker	Standing
	T9 *	7	F	Spastic diplegia	3	Bilateral AFO, elbow crutches	Sitting
	T10	11	M	Spastic quadriplegia	4	Bilateral AFO, gaiters, reciprocal walker	Standing

*** drop-outs**

PRIMARY OUTCOME MEASURES

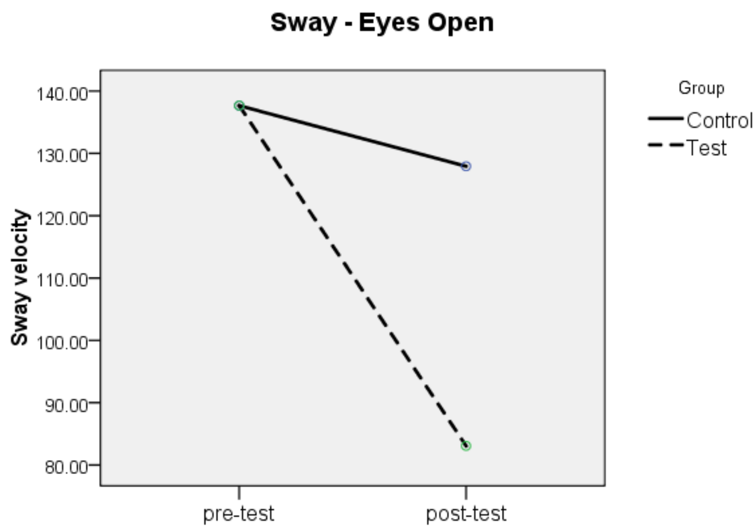
Posture control (balance) was the primary outcome. Static posturography to assess sway velocity and the Pediatric Berg's Balance Scale were used to assess posture control in these children.

A. STATIC POSTUROGRAPHY:

The children were asked to stand on the force plate (with all aids placed outside the platform) and bear as much weight as possible on the lower limbs. The position of the center of pressure (CoP) was detected by the force plate every $1/110^{th}$ of a second for 8 seconds. The sway velocity was calculated by estimating the distance traced by the CoP per second. Recordings were done with eyes open and eyes closed. A good posture control was indicated by low sway velocity.

There were no statistically significant difference in sway velocity at baseline between the control and intervention group either with eyes open (137.66 vs. 137. 67, p =0.508) or eyes closed (120.33 vs. 131.29, p=0.508). Following the intervention, sway velocity showed a decrease in the intervention group with both eyes open and closed. However, these changes were not statistically significant when compared to changes in the control group (Fig 1).

A.



B.

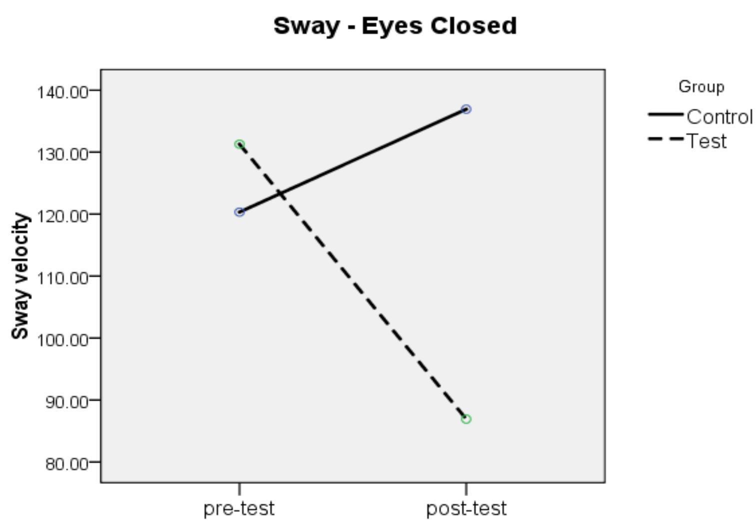


Figure 11: Change in sway velocity (mm per sec) with eyes open (A) and eyes closed (B).

Table 5: Sway velocity (mm per sec) with eyes open

Group		Mean	Std. Error	p-value (pre-test vs post-test)	p- value (control vs. intervention group)
Control	Pre-test	137.664	47.99	0.214	0.417
	Post-test	127.934	25.865		
Intervention	Pre-test	137.669	47.99	0.953	
	Post-test	83.064	25.865		

Table 6: Sway velocity (mm per sec) with eyes closed

Group		Mean	Std. Error	p-value (pre-test vs post-test)	p- value (control vs. intervention group)
Control	Pre-test	120.33	47.458	0.110	0.269
	Post-test	136.932	30.943		
Intervention	Pre-test	131.289	47.458	0.767	
	Post-test	86.921	30.943		

B. PEDIATRIC BERG'S BALANCE SCALE:

The Pediatric Berg's Balance Scale helps in measurement of balance by assessing performance in a series of functional tasks. It consists of a 14-item scale with each item scored within a range of 0 to 4. Hence the child can get a maximum score of 56 and minimum of 0.

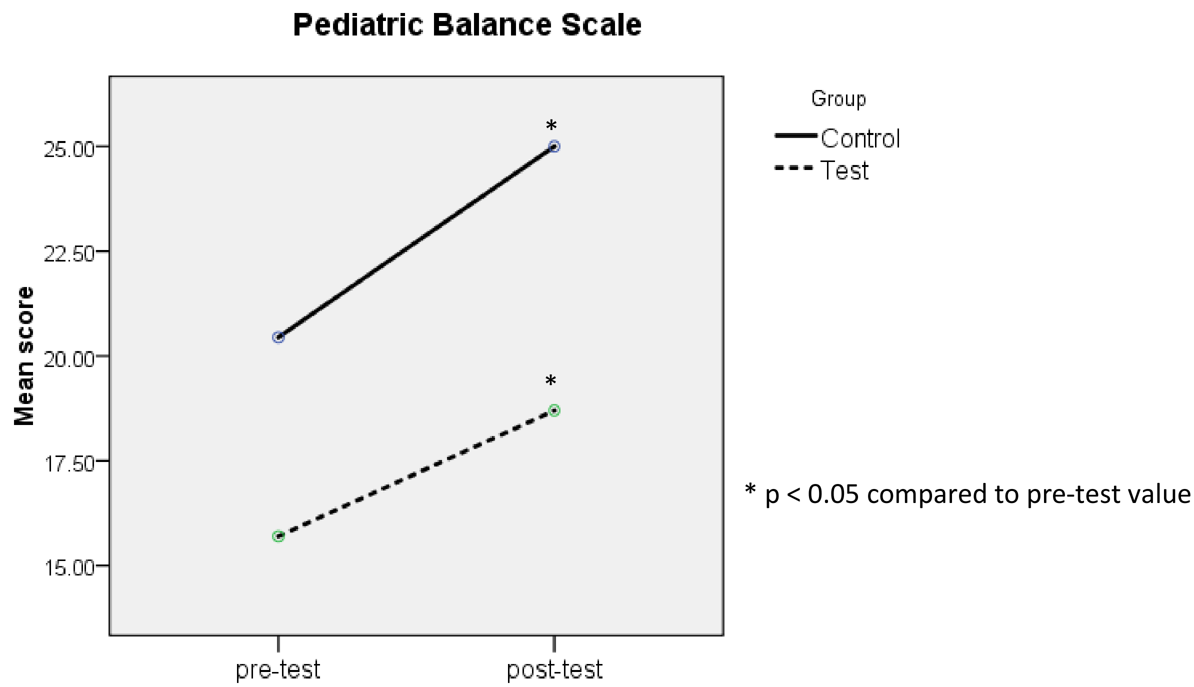


Figure 12: Changes in mean scores in the Pediatric Berg's Balance Scale

Table 7: Pediatric Berg's Balance Scale

Group		**Mean**	**Std. Error**	**p-value (pre-test vs post-test)**	**p- value (control vs. intervention group)**
Control	pre-test	20.444	5.649	**0.012**	0.285
	post-test	25	5.665		
Intervention	pre-test	15.7	5.359	**0.017**	
	post-test	18.7	5.374		

At baseline, no significant differences existed between the two groups. As shown in Fig 2, the scores obtained by children in the post-test in both control and intervention groups were significantly higher than those at baseline (pre-test values) in each group. The mean value for the increase in score (post-test minus pre-test) in the control group was 4.6 and in the intervention group was 3.0. However, no significant differences were found between changes in the intervention and control group (p=0.285).

SECONDARY OUTCOME MEASURES

A. UPPER LIMB AND HAND FUNCTION:

a. Box and block test:

The box and block test is a simple test that assesses hand function by counting the number of blocks a child can transfer to a box in a given time. The right and left hands are assessed separately and cumulative scores were calculated.

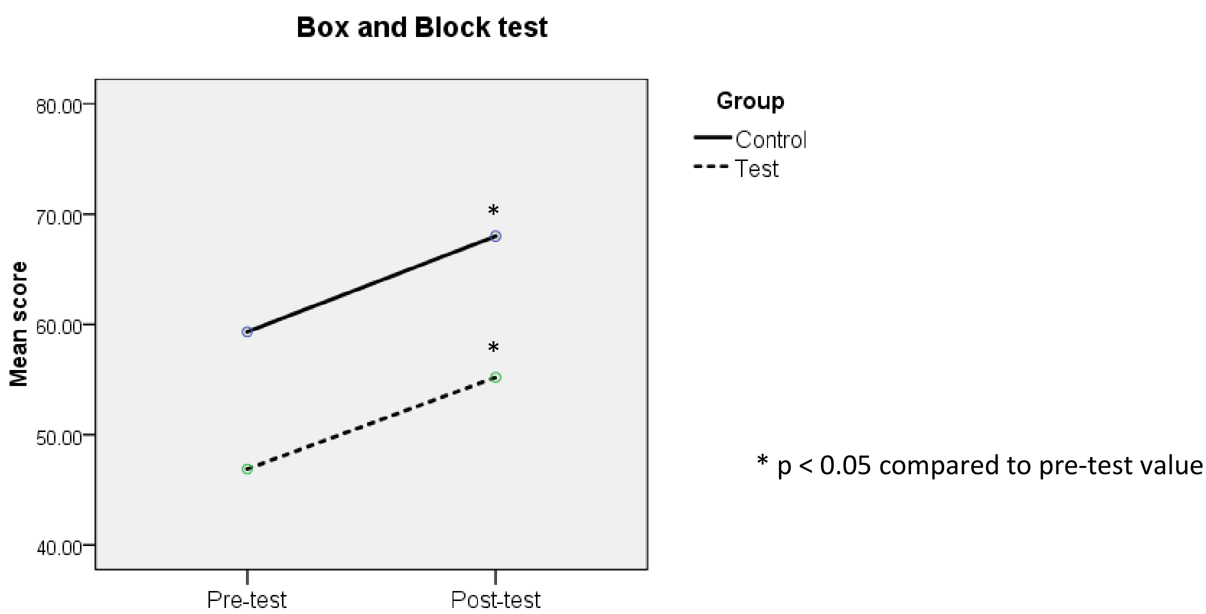


Figure 13: Changes in mean scores obtained in the box and block test (cumulative of right and left hand).

Table 8: Box and block test

Group		Mean	Std. Error	p-value (pre-test vs post-test)	p- value (control vs. intervention group)
Control	Pre-test	59.333	7.492	**0.015**	0.91
	Post-test	68	7.81		
Intervention	Pre-test	46.9	7.108	**0.005**	
	Post-test	55.2	7.409		

No significant differences were seen between the control and intervention groups at baseline (pre-test). The post-test showed significant improvements in both groups. The mean value of the difference (post-test minus pre-test) in the control group was 8.7 and in the intervention group was 8.3. No significant differences were found between changes in the intervention and control group (p=0.91).

b. Quality of Upper Extremities Skills Test (QUEST)

QUEST is a standardized test that assesses upper limb and hand function. The dissociated movements and grasp domains of this test was assessed in this study. The total score was also calculated.

i. ***Dissociated movements*:**

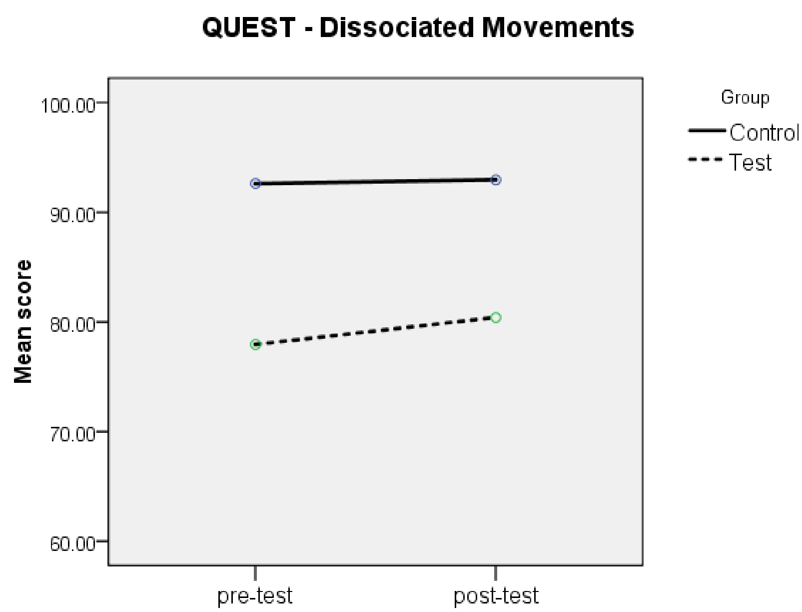


Figure 14: Changes in mean scores obtain in the dissociated movements module of QUEST

Table 9: QUEST – dissociated movements

Group		Mean	Std. Error	p-value (pre-test vs post-test)	p- value (control vs. intervention group)
Control	Pre-test	92.607	5.49	0.317	0.336
	Post-test	92.956	5.287		
Intervention	Pre-test	77.941	5.49	0.180	
	Post-test	80.406	5.287		

No significant differences were seen in scores obtained at baseline between the control and intervention groups. The intervention group showed a small improvement in the post-test compared to pre-test, however, this was not significant (p=0.18). No differences were seen when changes in intervention group were compared to those in the control group (p=0.336).

ii. ***Grasp:***

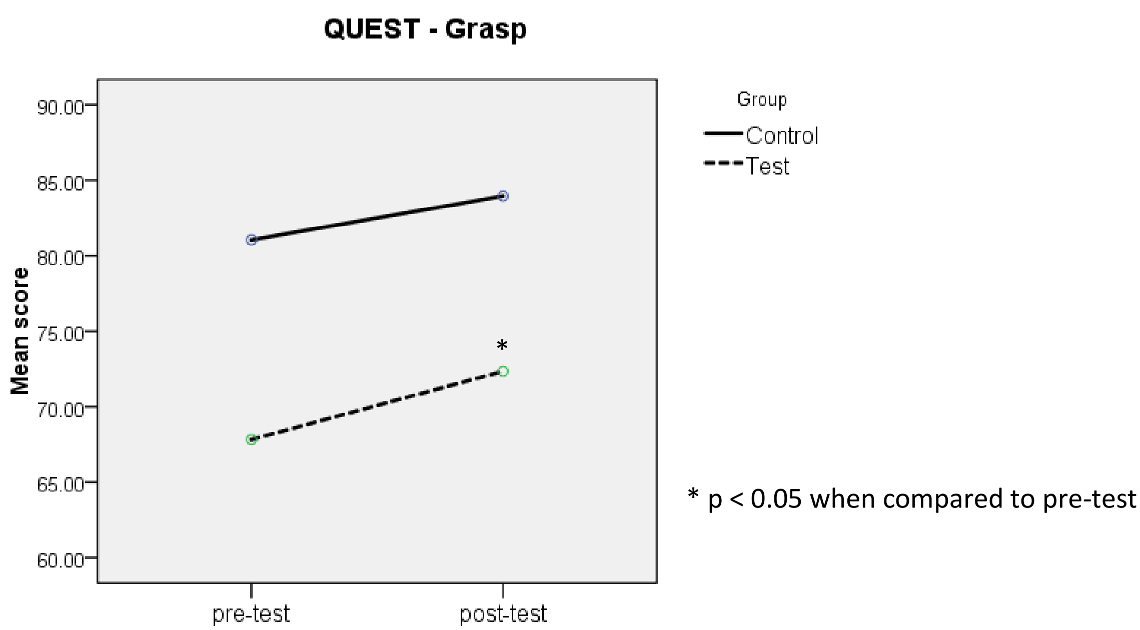


Figure 15: Changes in mean scores obtain in the grasp module of QUEST

Table 10: QUEST – grasp

Group		Mean	Std. Error	p-value (pre-test vs post-test)	p- value (control vs. intervention group)
Control	Pre-test	81.052	6.71	0.109	0.485
	Post-test	83.948	6.433		
Intervention	Pre-test	67.823	6.71	**0.039**	
	Post-test	72.348	6.433		

No significant differences between groups were seen at baseline. The intervention group showed a significant increase in mean score in the post-test compared to pre-test (p=0.039). Mean scores in the control group tended to improve as well, but these were not significant (p=0.109). When changes in the control group were compared to changes in the intervention group, no significant differences were seen (p=0.485).

iii. ***QUEST total score:***

The total score for QUEST was calculated as the total score obtained for the dissociated movements and grasp component of the test.

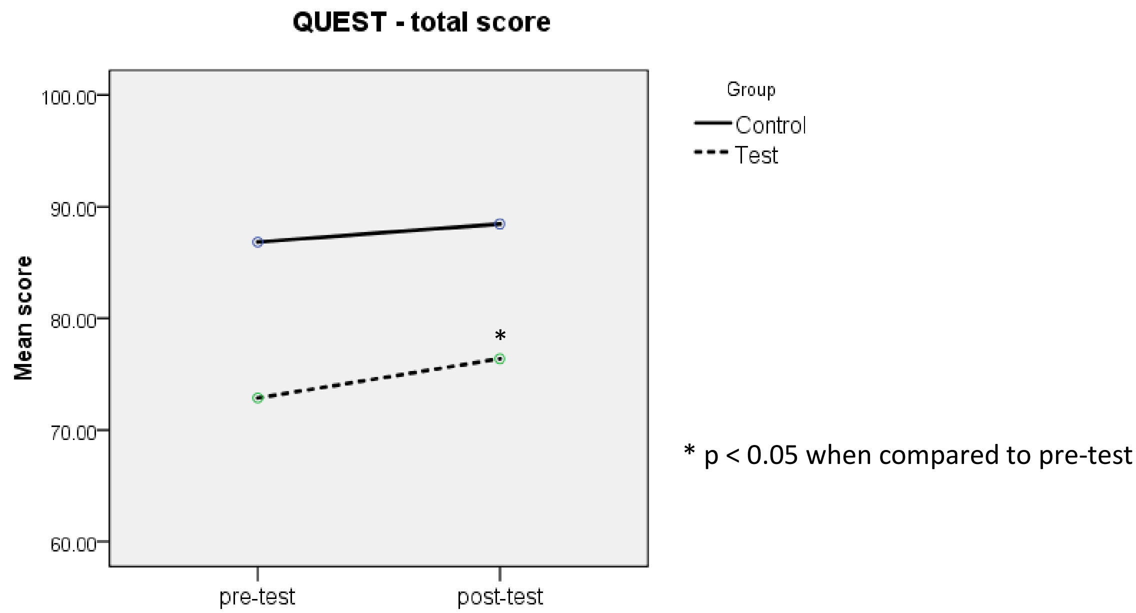


Figure 16: Changes in total scores obtain in QUEST (dissociated movement and grasp modules)

Table 11: QUEST – total score

Group		**Mean**	**Std. Error**	**p-value (pre-test vs post-test)**	**p- value (control vs. intervention group)**
Control	Pre-test	86.83	5.798	0.109	0.202
	Post-test	88.452	5.139		
Intervention	Pre-test	72.861	5.798	**0.027**	
	Post-test	76.378	5.139		

No significant differences were seen in the mean scores obtained in the pre-test in both groups. As seen in the results for the grasp module, total scores obtained in the post-test for the intervention group was significantly increased compared to pre-test (p=0.027). In the control group, no significant change was seen between the post and pre-test values (p=0.109). When changes in the intervention group were compared to changes in the control group, no significant differences were seen (p=0.202).

B. TEST FOR VISUAL PERCEPTUAL SKILLS (3rd edition) (TVPS)

The TVPS is a specialized test designed to assess various aspects of visual perception. This test includes 7 sub-tests that are designed to assess integration of visual perception and action.

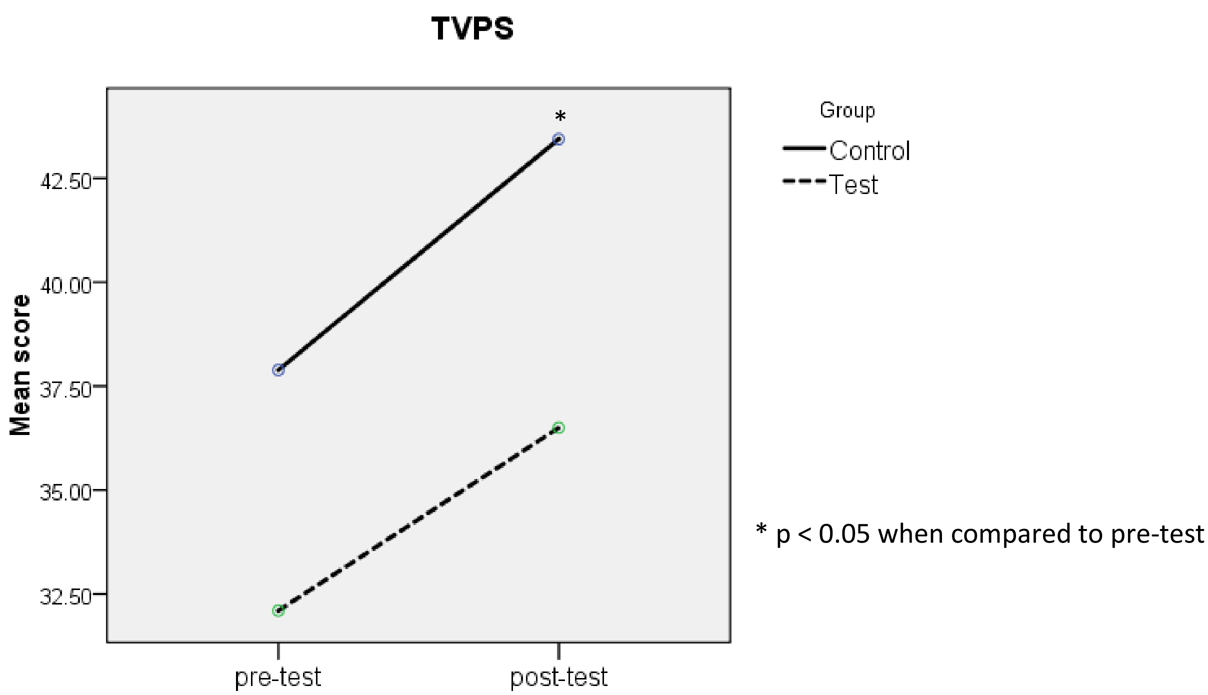


Figure 17: Changes in mean scores in TVPS

Table 12: TVPS

Group		Mean	Std. Error	p-value (pre-test vs post-test)	p- value (control vs. intervention group)
Control	Pre-test	37.889	3.934	**0.017**	0.649
	Post-test	43.444	4.137		
Intervention	Pre-test	32.1	3.732	**0.058**	
	Post-test	36.5	3.925		

No significant differences were seen in the pre-test between the two groups. In both the control and intervention group, mean scores for TVPS increased. The mean value of the difference (post-test minus pre-test) in the control group was 5.555 and in the intervention group was 4.4. This was statistically significant in the control group (P=0.017) and very close to statistical significance in the intervention group (p=0.058). The changes seen in the intervention group were not significantly different from those in the control group (p=0.649).

C. FUNCTIONAL AMBULATION

The ambulation was assessed by measuring the walking speed and endurance.

a. Walking speed:

Walking speed was assessed by asking the child to walk for 1 min at a self-selected walking speed.

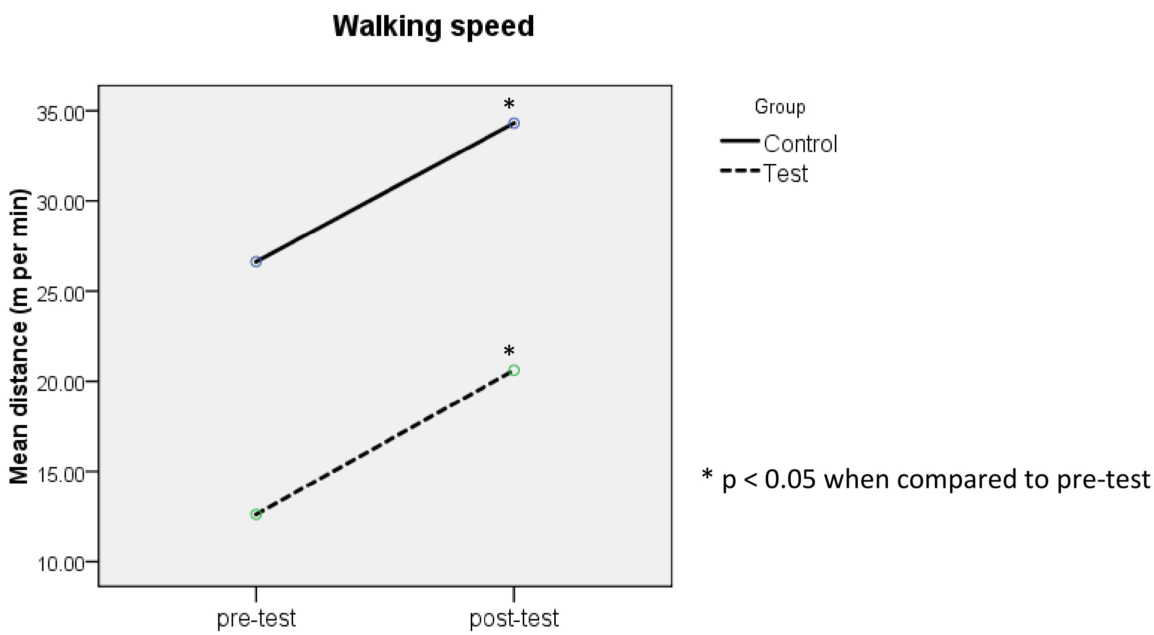


Figure 18: Changes in mean walking speed (m per min)

Table 13: Walking speed

Group		Mean	Std. Error	p-value (pre-test vs post-test)	p- value (control vs. intervention group)
Control	Pre-test	26.625	9.752	**0.042**	0.949
	Post-test	34.312	12.128		
Intervention	Pre-test	12.611	9.194	**0.017**	
	Post-test	20.611	11.434		

There was no difference in the walking speed in the pre-test between control and intervention groups. Both control and intervention group showed significant increases in the post-test compared to pre-test (p=0.042 for control group and p=0.017 for intervention group). The mean value of the difference (post-test minus pre-test) in the control group was 5.95 and in the intervention group was 7.2. However, no significant differences were seen in the changes in intervention group compared to changes in control group (p=0.949).

b. Endurance:

Walking endurance was assessed as the maximum distance the child was able to walk at a stretch without a rest period.

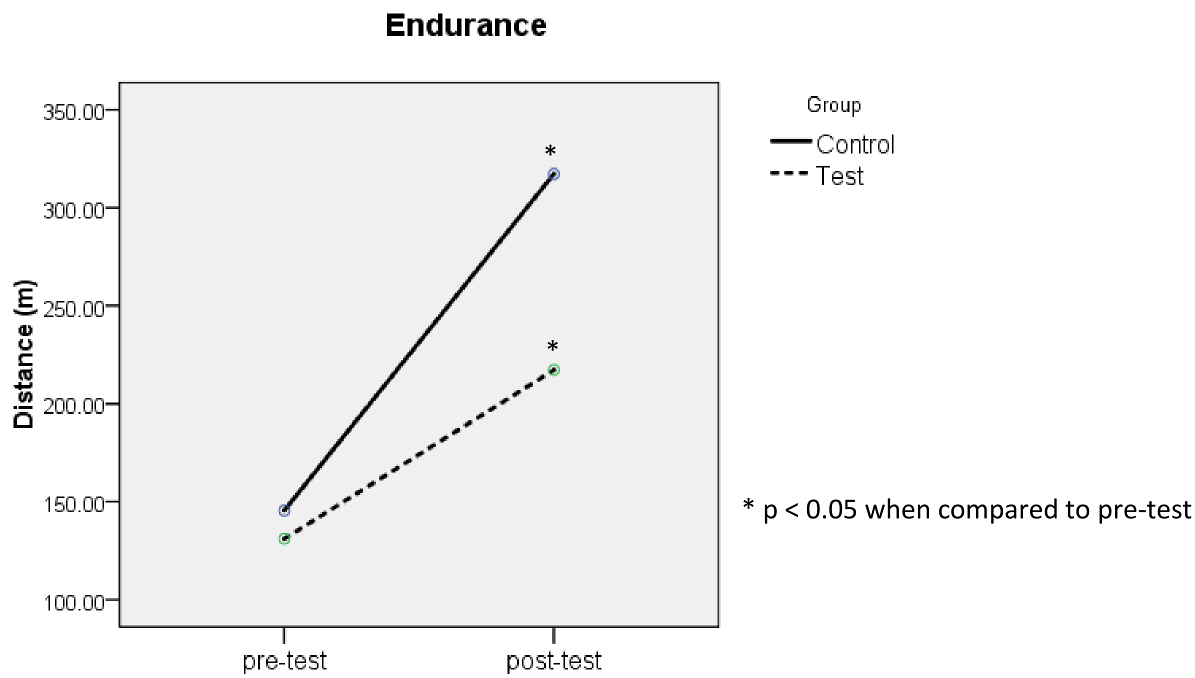


Figure 19: Changes in walking endurance (m)

Table 14: Walking endurance

Group		**Mean**	**Std. Error**	**p-value (pre-test vs post-test)**	**p- value (control vs. intervention group)**
Control	Pre-test	145.556	59.767	**0.012**	0.348
	Post-test	317.222	86.544		
Intervention	Pre-test	131.1	56.7	**0.028**	
	Post-test	217.2	82.103		

There were no significant differences between pre-test values in the two groups. Control as well as intervention group showed significant increases in the post-test compared to pre-test (p=0.012 for control group and p=0.028 for intervention group). No significant differences were seen in the changes in intervention group compared to changes in control group (p=0.348).

Discussion

DISCUSSION

The concept of virtual reality (VR) has been around for more than a century. However, its applications in everyday life have sky-rocketed during the last couple of decades. Virtual reality gaming is extremely popular with Nintendo Wii, Sony PlayStation and Microsoft Xbox leading the way in exploring newer and novel technologies that make virtual reality more and more “real”.

The use virtual reality (VR) technology as a therapeutic tool still remains a relatively new intervention modality. Preliminary research in this area is just emerging. It is obvious that the potential uses of VR in the field of rehabilitation are vast. Nevertheless, thorough validation of research findings is necessary as the currently available literature is scarce (Snider et al., 2010).

The great advantage of VR in rehabilitation, especially among children, is the fact that it provides opportunities for active learning in a motivating environment that is challenging and safe. The large variety of stimuli that can be given, the ability to control difficulty based on individual requirements and ability to record the outcomes help clinicians and therapists to tailor the therapy programme for each individual child to suit individual needs. Children who often do not comply with conventional exercise programs tend to be more motivated to follow exercise programs based on VR games (Harris and Reid, 2005).

In this study we have looked at the effectiveness of the Nintendo Wii gaming in rehabilitation of children with CP. It was offered to the intervention group as a supplement to routine therapy. These children continued to receive therapy as prescribed by the physiatrist; in addition, they played Wii games during a 45 minute slot during normal therapy time. This was done 6 days a week for 3 weeks. Thus, they received a total of 18 such play-sessions. A control group was also assessed who received routine therapy only.

Routine therapy in the department of PMR, CMC, consists of both physiotherapy and occupational therapy. It is a goal-directed, comprehensive rehabilitation programme that involves a team of physiatrists, physiotherapists, occupational therapists, speech therapists, psychologists, rehabilitation nurses and social workers, who meet regularly to plan and assess the patient's progress. The total duration of therapy per week is approximately 36 hours which includes group discussion and other group activities. The individual components of therapy will depend on each child`s specific needs. In general, physiotherapy consists of strengthening exercises for the weak muscles, stretching exercises for the spastic muscles and ambulation training. Occupational therapy consists of activities to improve hand function, developmental positioning and cognitive training. In addition, some children will require speech therapy to improve speech and communication.

The primary outcome measured was posture control and balance. Difficulty in this area is one of the major concerns in children with CP and has implications in self-care and independence. Improvement in balance helps them to improve their ambulation, participation in activities of daily living and overall self-esteem (Shih et al., 2010). Since the Wii games chosen (tennis and boxing) required the child to actively adjust posture in order to play the game, it was felt that it would have a beneficial effect on posture control. In the virtual tennis game, the child, if playing in the standing posture, would be required to shift weight from one leg to the other and also appropriately adjust posture, in order to play a forehand shot or a backhand shot. In the virtual boxing game, the child would have to shift the center of gravity forward in order to throw a punch, or backward, in order to defend against the opponent's punch. It has already been shown in a few studies that Wii games in stroke patients significantly improved balance and ambulation (Saposnik et al., 2010; Saposnik and Levin, 2011).

It would be expected that benefits of playing Wii games on posture control would be greater if the games were played in the standing posture, as it allowed weight-bearing on the lower limbs and greater room and freedom to move around. However, if the game was played in the sitting posture, it would still require the child to actively adjust posture to make a shot, albeit, to a lesser extent than in standing posture. In our study, 3 out of 10 children in the intervention group played games in the sitting posture. The reason for this was the fact that children with poor balance were very likely to fall down and hurt themselves while playing the games. All the children were initially asked to play the games while standing. However, those who could not manage to do this were allowed to play in the sitting posture.

We found that, among the children in the intervention group, sway velocity in the post-test decreased marginally (indicating an improvement in posture control and balance) with eyes open (fig 1A) and with eyes closed (Fig 1B), but the change was not statistically different compared to the pre-test. No change was seen in the control group. Since sway velocity measures balance in the standing position, it is possible that the fact that 3 out of 10 children played the games in the sitting position may have had a significant bearing on the statistical significance of the outcome of the intervention. We would expect greater improvement in balance to be achieved if the games were played while standing as there would be increased weight shifting while playing games. We speculate that if all children played in the standing position, sway velocity would have given a more reliance estimate of the effectiveness of Wii games in improving balance while standing.

The Pediatric Berg's Balance scale assesses balance on the basis of the ability of the child to perform 14 different tasks (Appendix 3). These tasks include those done in the standing or sitting posture, or both. This test is therefore equipped to detect improvements in posture and balance in the sitting position as well, in contrast to measurement of sway velocity, which is assessed only in the standing position. The results of this study showed that mean scores in both control and intervention groups significantly improved in the post-test compared to pre-test. Again, the improvements in the intervention group were not significantly better than in the control group (Fig 2).

To conclude, the study suggests that Wii games did not show significant improvements beyond those achieved with routine therapy in the primary outcome of this study which is posture control and balance. In addition, the study also shows that the routine therapy that these children received (in both control and intervention groups) contributed significantly to improving posture control and balance in the sitting position, while that in the standing position was not significantly improved. Therefore, greater emphasis on posture control training in the standing position, may contribute significantly in improving the therapy regimen for children with CP.

Among the secondary outcomes observed, upper limb and hand function was assessed by QUEST and the box and block test. QUEST is a standardized test that has been validated in children with CP (Thorley et al., 2012) that has 4 different modules (Appendix 4). The "dissociated movement" module and the "grasp" modules were assessed in this study based on the results obtained from the case report published by Deutsche et al 2008. Even though, the intervention group showed a marginal improvement in mean scores obtained in the dissociated movements module, these changes were not significant (Fig 4). In the grasp module, intervention group showed a significant improvement in the post-test compared to pre-test (Fig 5). This was not seen in the control group, suggesting that Wii games had beneficial effects on grasp that were significantly greater than those achieved by routine therapy.

Grasp or prehension consists of power grip (full-hand prehension) or precision handling (finger-thumb prehension). The grasp module of QUEST assesses both these types: full-hand prehension (holding a block in different ways) and precision handling (holding a grain between finger and thumb, and holding a pencil in different ways). Playing the tennis game was expected to improve grasp, especially full-hand prehension in the dominant hand, as the child has to hold on to the Wii remote, which is shaped like the handle of a tennis racquet, very tightly. A better grasp will allow the child to play a point in the tennis game for longer durations. This would provide the motivation to grasp the remote better and improve this function in the process. In the boxing game, the child has to hold the Wii remote in one hand and a similarly styled device called the nunchuck in the other hand. The child throws punches with both hands, and therefore, grasp in both hands is expected to improve. The results of this study showed that Wii games indeed improved grasp to a greater extent than that achieved by the routine therapy (Fig 5). In addition, the total score for QUEST, which was computed as the sum of scores obtained for the dissociated movement module and the grasp module of QUEST, was significantly greater in the intervention group.

The box and block test primarily assesses manual dexterity. Here the child is asked to transfer as many blocks (1 inch cube size) as possible from one box to another. The results of this test showed, significant improvements in both the control and intervention groups

(Fig 3). However, the improvements in the intervention group were not significantly better than those in the control group. This showed that the beneficial effect of Wii games on manual dexterity was not significantly greater than those given by routine therapy. This is probably related to the fact that playing Wii games laid greater emphasis on full-hand prehension than on precision handling. The box and block test assessed the ability of the child to precisely hold the block (finger-thumb prehension) and then transfer it to a different box. This function was probably not improved significantly by the Wii games.

Visual perceptual skills, as assessed by the Test for Visual Perceptual Skills – 3rd edition (TVPS – 3), was another secondary outcome of this study. TVPS-3 has been validated in CP (Tsai et al., 2009). It consists of 7 subsets that test various aspects of integration of visual perception and action (Appendix 5). Playing Wii games requires the child to visualize the virtual environment created on the television screen, detect movement and the respond appropriate through body movements. Hand-eye co-ordination is a key aspect of playing these games. Therefore, good visual perception contributes greatly to the ability of children to play these games well. It would also be expected that playing these games would lead to improvements in visual perception. This has been shown in a few previous studies. These were the reasons why improvement in visual perception was included as one of the secondary outcomes of this study.

The results indicate that the control group improved significantly in the post-test compared to the pre-test (Fig 7). The intervention group also improved; however, the p-value for this group was just above the cut-off of $p < 0.05$ ($p=0.058$) that was taken to indicate statistical significance. This may be related to the greater variability in the scores obtained for the intervention group. Improvements seen in the intervention group was not significantly different from those seen in the control group. Again, this showed that the beneficial effects of Wii games were not significantly greater than those of routine therapy that the children received. The reason for this may be related to the time required for significant changes in visual perception to become apparent. Perhaps, the three-week (18 sessions) programme selected for this study was insufficient to produce significant improvement in visual perception.

The ability of children with CP to ambulate independently is of great importance to their quality of life. Since Wii games motivate CP children to physically exert themselves, it was hypothesized that this may lead on to improvement is their functional mobility as well. Walking speed and walking endurance were estimated as measures of functional mobility. Walking speed and endurance was significantly improved in both control and intervention groups. However, the improvements seen in the intervention group were not significantly greater than those seen in the control group. This suggested that Wii did not add to the beneficial effects of routine therapy in functional ambulation. Children playing Wii games tend to physically exert themselves; however, they are, for most part, stationary. The fact that Wii games *per se* do not require children to be mobile may be one of the reasons for the lack of improvements seen in this aspect. In addition, the fact that 3 of the 10 children in the intervention group played Wii games in the sitting posture may have resulted in limited improvements in lower limb function seen in this group.

To summarize the major findings, this study showed that Wii games did not have a significant effect on improvement in balance and posture control, which was the primary outcome of this study. In the intervention group, Wii games significantly improved upper limb and hand function, which was not seen in the control group. Visual perception and functional mobility, on the other hand, did not show significant improvements compared to the control group. The results of this study add to the scare literature available on the effectiveness of Wii games in CP rehabilitation.

The primary and secondary outcomes for the current study were chosen based on a case report published by Deutsche et al. in 2008. In fact, this was the first study that looked at Wii games as a potential therapeutic tool in CP rehabilitation. Deutsche et al reported encouraging finding which prompted us to do a pilot study to confirm their findings. The other studies which have also looked at Wii games in CP rehabilitation (Table 3 in the review of literature) were published in the last 2 years during the time in which this study was on-going. As with these studies, our study also has a small sample size (n= 20, with n=10 in the intervention group and n=10 in the control group), however, the study design has several advantages as described below.

As listed in Table 3 of the review of literature section, there have been 5 studies done over the last 6 years that have assessed Wii games in CP rehabilitation. Out of these five, four were within-group studies (Gordon et al., 2012b; Jelsma et al., 2013; Ramstrand and Lygnegård, 2012; Tarakci et al., 2013; Winkels et al., 2013). In these studies, children were assessed before and after a regimen that consisted exclusively of Wii games (without routine therapy) and significant differences between pre and post-tests were looked for. In all the studies, Wii games were found to be effective in improving the parameters that were studied. However, no information was provided on whether these improvements were better than those obtained from the routine therapy these children were receiving. As a result no meaningful conclusion regarding the effectiveness of Wii games compared to routine therapy could be arrived at. This drawback has been addressed in this study which has compared all outcomes in the intervention group (Wii games plus routine therapy) with those obtained in a control group that received routine therapy alone.

In one study (Ramstrand and Lygnegård, 2012), a cross-over trial was done where children received a 5-week home-based Wii games program and then crossed-over to a 5-week regimen of routine therapy, or vice-versa. Improvement in balance was tested as one of the primary outcomes. The results showed that none of the tests assessing balance showed a significant improvement compared to routine therapy. The results of our study are therefore in agreement with those obtained in the study done by Ramstrand et al.

The five studies mentioned above that assessed Wii games in cerebral palsy primarily looked at balance, upper limb function or motor performance as the major outcomes. However, as shown in table 3, the specific tests chosen to measure these outcomes vary considerably between the studies. This makes it very difficult to compare results from one study with another. In addition, all of these studies are small, with sample sizes varying from 7 (Gordon et al., 2012b) to 18 (Ramstrand and Lygnegård, 2012).

Apart from Nintendo Wii, a number of other virtual reality gaming technologies have been used in CP rehabilitation (Table 1 and 2 in the review of literature). These include commercially available gaming consoles as well as custom designed technologies like IREX (Interactive Virtual Reality Exercise System). A wide variety of outcome measures have been evaluated and, in most studies, use of virtual reality games was found to be beneficial. However, despite the fact that a large number of pilot studies have provide encouraging results, no large studies have been published to-date. This remains a major hurdle in evaluating the beneficial effects of virtual reality gaming in CP rehabilitation.

The results of this study showed that many of the outcomes studied (sway velocity, Berg's balance scale, QUEST, box and block test and TVPS) showed a trend towards improvement, which was, nevertheless, not significant compared to control group. This is probably related to the small sample size (n=10 in each group). It is therefore possible that a larger study, with sample sizes calculated based on the results of this study, could show a significant beneficial effect of Wii games in CP rehabilitation. It is also possible that a longer duration of the Wii games may have a better effect on the outcome.

Another factor which is also noteworthy is the fact that, despite the small sample size in this study, none of the parameters studied were significantly different between the control and intervention groups at baseline (pre-test). This indicates that the randomization protocol in this study was effective and both groups (control and test) were similar at baseline. This is also one of the strengths of this study. In addition, none of the parameter showed a decline in performance in the intervention group, showing that there were no obvious adverse effects associated with playing Wii games. Even though only upper limb and hand function (as assessed by QUEST) showed statistically significant improvements compared to the control group, it is possible that the cumulative effect of improvements in multiple domains can enhance the overall performance of the CP children exposed to VR gaming therapy.

It was observed that all the children in the intervention group were enthusiastic and motivated to play the Wii games. There is anecdotal evidence from telephonic interviews with the participants done after the completion of the study that all the children enjoyed being part of the study. One of the participants went on to purchase a Wii gaming console to continue playing it at home. In fact this child plays the games regularly with his sibling. This indicates that this form of therapy can be expected to have high compliance as the children continue to enjoy playing these games at home after they have returned from a hospital setting where routine therapy was given. It is known that one of the most important barriers in CP rehabilitation is the low compliance with conventional exercise regimens at home or in a school setting. This is an area where Wii games can have significant advantage over conventional therapy. In this context, it is possible that Wii games can be introduced as a “reward” for the CP children in order to improve compliance to conventional exercise programs.

The safety of children while playing Wii games was one of the major concerns. The participants and their parents were informed about the minimal risk of injury while playing these games. All the games were played under the supervision of an occupational therapist. There were no incidents reported during the conduct of this study where a child had fallen or was injured in any way. Of the ten children who played the games, three had very poor balance and were, therefore, allowed to play the games in the sitting position.

In this study, tennis and boxing games were chosen for all children in the intervention group. This was done to ensure uniformity. But in a home setting, the type of Wii game can be chosen based on individual preference and therapeutic need for each child. There is a wide variety of Wii games that are available commercially. In addition, it is quite possible that the findings can be extrapolated to other virtual reality gaming technologies like the Sony PlayStation or Microsoft Xbox as well.

Virtual reality gaming provides CP children with an opportunity to be involved in competitive sports with their peers which they might be unable to do in the natural outdoor setting. This can help the child to improve his/her self-esteem and confidence. The settings in the virtual reality gaming consoles can be adjusted depending on the player's skill level. Once a child`s performance improves at a particular level, the game can be upgraded to the next level, thus providing novelty and continuity. The child will also be able to assess his/her own performance and this will help in biofeedback.

There were a few practical difficulties that were encountered during the intervention and the assessments. These are briefly discussed here below. The children in the intervention group were allowed to play the Wii games based on the compliance and cooperation of the children during these sessions. However, the necessary numbers of sessions, 18 in all, were completed for all the children. In this study we had 2 parameters that assessed the primary outcome and 4 parameters that assessed the secondary outcomes. These assessments would frequently take a long time and exhaust the children. We found that children find it difficult to co-operate for the detailed assessment of multiple outcome measures. This could have added to the possibility of errors in measurement of the outcomes.

One of the concerns of the parents of CP children is the continuity of therapy as they leave the institutional rehabilitation facilities. Wii games could be used as a substitute in the home setting which shows outcome measures similar to standard therapy. Hence this could be a simple, home-based, child-friendly measure for on-going therapy.

Limitations of the study:

1. The study was done as a pilot study with 20 children. Therefore the results obtained should be used to design larger studies to confirm the effects of this intervention in CP rehabilitation.

2. There was no follow up assessment of the outcome measures. Outcome measures were done immediately post intervention. Due to time constraints that are involved in a MD dissertation, a longer term follow-up was not done. This would have provided more information regarding the effectiveness of the intervention.

3. A telephonic interview with the participating children and his/her parents was used to assess satisfaction and obtain feedback regarding the intervention. This could have been done in a more systematic manner by using a standardized questionnaire administered immediately post intervention.

Scope for further research:

A larger study can be designed with increased sample size and long-term follow up. The results of this study would be useful in the calculation of the sample size for such a study.

Conclusions

CONCLUSIONS

The major findings of this study were as follows:

- A significant improvement in the "grasp" sub-test and total score of QUEST was seen in the post-test compared to pre-test in the intervention group, which was not seen in the control group. However, changes in the intervention group, when compared to those in the control group, were not statistically significant.

- There were no statistically significant effects on posture control and balance in the intervention group compared to the control group.

- Visual perceptual skills and functional mobility measures were not significantly improved in the intervention group compared to control group.

- None of the outcome measures showed any evidence of deterioration in the intervention group as compared with control group.

- Children in the intervention group were highly motivated and enjoyed playing Wii games as part of their therapy sessions.

We conclude that Wii games-based therapy can be offered as an effective adjunct to routine therapy in CP rehabilitation. However, a larger study will have to be designed in order to come to definite conclusions regarding the beneficial effect of this intervention.

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LIST OF ANNEXURES:

1. Informed consent forms
    a. English
    b. Tamil
    c. Hindi
    d. Bengali
    e. Malayalam
    f. Telugu
2. Child’s assent form
3. Informed consent for use of photographs
4. Box and block test instructions
5. Pediatric berg’s scale instructions and scoring sheet
6. QUEST instructions and scoring sheets
7. TVPS description and instructions.

PATIENT INFORMATION SHEET

Title of the study: Use of Nintendo Wii™ gaming console for rehabilitation of children with cerebral palsy
Principal Investigator: Dr. Jane Elizabeth Sajan
Department: Physical Medicine and Rehabilitation (PMR), CMC, Vellore

Cerebral palsy is characterized by poor balance and posture control, in addition to other developmental problems. This significantly impairs the child's ability to independently perform day-to-day activities. The Nintendo Wii™ (Wii) is a commercially available gaming console that allows the user to play games in a virtual environment. The Department of Physical Medicine and Rehabilitation (PMR), CMC, Vellore, is carrying out a study to determine whether children with cerebral palsy benefit from playing virtual reality games (interactive video games) using Nintendo Wii™. If you are agreeable for your child to be part of this study, he/she will be included in this study. Once included, your child will be randomly allocated into two groups – group A and group B. The allocation to either group will be entirely by chance and your child will have equal chance to be in either group. If your child is in group A, he/she will be requested to play Wii games for 45-60 minutes per day, 6 days a week, for 3 weeks (18 sessions in total). Your child will continue to receive routine rehabilitation therapy in the department. If your child is in group B, he/she will be given routine therapy and will NOT be required to play Wii games. Before the start of study and after the completion of the study (after 3 weeks), standard tests to assess balance, mobility and visual perception will be done for your child. By this study we hope to find out whether Wii games can improve balance and posture control, mobility and visual perception in children with CP.

Participation in this study is not likely to cause harm to your child's health in any foreseeable manner. All your personal information obtained by us from you will be kept completely confidential. If you do not want your child to participate in this study, you are free to say so. You can also choose to withdraw your child from the study at any time without being obliged to provide an explanation. This will not affect the treatment that your child will receive in this hospital in any way.

If you need additional information, you are welcome to contact us. Contact information is available below. Additional information on Nintendo Wii™ and the assessment tests that will be used in this study will be provided on request.

Dr. Jane Elizabeth Sajan
Department of Physical Medicine and Rehabilitation
Christian Medical College,
Bagayam, Vellore, Tamil Nadu - 632002
INDIA
Phone: +91 – 9500834052 (mobile)
E-mail: janesajan@gmail.com

INFORMED CONSENT

Title of the study: Use of Nintendo Wii™ gaming console for rehabilitation of children with cerebral palsy
Principal Investigator: Dr. Jane Elizabeth Sajan
Department: Physical Medicine and Rehabilitation (PMR), CMC, Vellore

I have read and understood the information sheet describing the study to me. ________________ has also explained the details of the proposed study to me. I have understood what has been said including the following:

1. If I give consent for my child to participate in this study, he / she may be required to play Wii games for 30 minutes per day, 6 days a week, for 3 weeks (18 sessions in total).
2. If required to play Wii games, I understand that it is not likely to adversely affect my child's health in any foreseeable manner.
3. I can choose not to give consent for my child to be part of this study. I can also choose to withdraw my child from the study at any time without being obliged to provide an explanation. In any case, my decision will not affect the treatment given to my child in this hospital.

I am willing to give consent for my child to be part of this study voluntarily and without any coercion from the investigators of this project.

Signature of legal guardian   Signature of investigator

Signature of witness

Date:

In case you have additional queries, please feel free to contact me:
Dr. Jane Elizabeth Sajan
Department of Physical Medicine and Rehabilitation
Christian Medical College,
Bagayam, Vellore, Tamil Nadu - 632002
INDIA
Phone: +91 – 9500834052 (mobile)
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நோயாளி தகவலறிவிப்பு தாள்

ஆய்வின் தலைப்பு : "பெருமூளை வாதத்தால் பாதிக்கப்பட்ட குழந்தைகளை நின்டென்டோ Wii™ என்ற விளையாட்டைப் பயன்படுத்தி அவர்களின் துயர் நீக்கி மறுவாழ்வளித்தல்".

முதன்மை புலனாய்வாளர் : Dr. ஜேன் எலிசபெத் ராஜன்

துறை : உடல் மருத்துவம் மற்றும் மறுவாழ்வு துறை (PMR)

உடல் சமநிலையின்மை, உட்காருவதில் கடினம் மற்றும் வளர்ச்சி பிரச்சினைகள் அனைத்தும் பெருமூளை வாதத்தால் வரும் குறிப்பிடத்தக்க மாற்றங்கள். இதனால் குழந்தையின் தனித்து செயல்படும் திறன் அன்றாட வாழ்வில் மாறுபடுகிறது. எனவே நின்டென்டோ Wii™ என்ற நிறுவனம் கற்பனை விளையாட்டை பயன்படுத்தி, இவர்களை விளையாடச் செய்து துயர் நீக்கி மறுவாழ்வளிக்க முன்வந்துள்ளது. எனவே உடல் மருத்தும் மற்றும் மறுவாழ்வு துறை இந்த நின்டென்டோ Wii™ என்ற கற்பனை விளையாட்டை பயன்படுத்தி பெருமூளை வாதத்தால் பாதிக்கபட்ட குழந்தைகளுக்கு ஏதேனும் முன்னேற்றம் ஏற்பட வாய்ப்புள்ளதா? என்பதை ஆய்வு செய்ய முன்வந்துள்ளது.

எனவே உங்களின் சம்மதத்துடன் உங்கள் குழந்தையை (அவன்/அவள்) சுமார் 45 நிமடம் முதல் 60 நிமிடம் வரை இந்த நின்டென்டோ Wii™ என்ற விளையாட்டை விளையாட செய்தோ (அ) மாதிரியாக பயன்படுத்தியோ ஏதாவது முன்னேற்றம் ஏற்படுகிறதா என்பதை கண்காணிக்கவும், இதே போல் இந்த விளையாட்டை தொடர்ந்து ஒரு வாரத்தில் ஆறு நாள் என்ற கணக்கில் 3 வாரம் (மொத்தம் 18 முறை) விளையாட செய்ய ஒத்துழைக்குமாறு கேட்டுக் கொள்கிறோம்.

உங்கள் குழந்தைக்கு விளையாடுவதற்கு முன்பும், விளையாடிய பின்பும் சில பொதுவான பரிசோதனைகள், உடல் சமநிலை, நகர்நிலை மற்றும் பார்த்ததும் அறிந்து கொள்ளக் கூடிய ஆற்றல் போன்ற சோதனைகள் மேற் கொள்ளப்படும்.

திருப்புக ...

இந்த விளையாட்டின் மூலமாக பெருமூளை வாதத்தால் பாதிக்கப்பட்ட குழந்தைகளுக்கு ஏற்படும் உடல் சமநிலையின்மை, நகர்நிலை மற்றும் உட்காரும் நிலை ஆகியவற்றில் ஏதேனும் முன்னேற்றம் ஏற்பட வாய்ப்புள்ளதா என்பதை ஆய்வு செய்ய பெருதவியாக இருக்கும்.

இந்த ஆய்வில் பங்கேற்பதால் உங்கள் குழந்தையின் உடல் ஆரோக்கியத்திற்கு எந்தவித பாதிப்பும் ஏற்படாது என்பதை தெரிவித்துக் கொள்கிறோம். உங்களின் அனைத்து சொந்த விஷயமும் எங்களால் ரகசியமாக பாதுகாக்கப்படும். ஒருவேளை உங்கள் குழந்தை இந்த ஆய்வில் பங்குபெற விருப்பமில்லையென்றால் தாராளமாக மறுப்பைத் தெரிவிக்கலாம். மேலும் இந்த ஆய்விலிருந்து தாங்கள் எந்த நேரமும், எந்தவித பதிலளிப்பும் இன்றி பின்வாங்கலாம். இதனால் இந்த மருத்துவமனையிலிருந்து உங்கள் குழந்தை பெற்றுவரும் சிகிச்சையில் எந்தவித மாற்றமும், எப்பொழுதும் ஏற்படாது என்பதை தெரிவித்துக் கொள்கிறோம்.

தாங்களுக்கு மேலும் ஏதேனும் விபரமறிய கீழ்கண்ட முகவரியில் தொடர்பு கொள்ளவும். உங்களுடைய எண்ணப்படத்தின் பேரில் நின்டெண்டோ Wii என்ற விளையாட்டை பற்றியும், அந்த விளையாட்டின் மூலம் உங்கள் குழந்தையின் முன்னேற்றத்திற்கான மதிப்பீடு அளவு பற்றியும் விபரமளிக்கிறோம்.

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விபரமறிந்து தெரிவிக்கும் அனுமதி

ஆய்வின் தலைப்பு : "பெருமூளை வாதத்தால் பாதிக்கப்பட்ட குழந்தைகளை நின்டென்டோ Wii™ என்ற விளையாட்டைப் பயன்படுத்தி அவர்களின் துயர் நீக்கி மறுவாழ்வளித்தல்"

முதன்மை புலனாய்வாளர் : Dr. ஜென் எலிசபெத் சாஜன்

துறை : உடல் மருத்துவம் மற்றும் மறுவாழ்வு துறை (PMR)

________________ இந்த ஆய்வைப்பற்றி அனைத்தையும் என்னிடம் விவரித்தார். அவர்கள் சொன்ன அனைத்தையும் நான் புரிந்து கொண்டேன். அவற்றுள் உள்ளடக்கிய சில...

1) நான் ஒப்புதல் அளித்தால் என்னுடைய குழந்தை இந்த Wii™ என்ற கற்பனை விளையாட்டை தினமும் 45 நிமிடம் முதல் 60 நிமிடம் வரை வாரத்தில் 6 நாட்களும், இவ்வாறாக மூன்று வாரம் (மொத்தம் 18 முறை) விளையாட அல்லது மாதிரியாக இருக்க ஒப்புதல் அளிக்கிறேன்.

2) இந்த Wii™ என்ற கற்பனை விளையாட்டை விளையாடுவதன் மூலம் என்னுடை குழந்தையின் ஆரோக்கியதிற்கு எவ்வித குறைபாடும் ஏற்படாது என்பதை அறிகிறேன்.

3) ஒரு வேளை இந்த ஆய்விற்காக நான் ஒப்புதல் அளிக்காமலும் போகலாம். இந்த ஆய்விலிருந்து எந்த நேரத்திலும், எவ்வித உடன்பாடுமின்றி, யாருக்கும் பதிலளிக்காமலும் விலகி கொள்ளலாம். நான் எடுக்கும் இந்த முடிவால் எந்த விதத்திலும் என்னுடைய குழந்தை இங்கு பெற்று வரும் சிகிச்சையில் மாற்றம் இருக்காது என்பதை நம்புகிறேன்.

என்னுடைய குழந்தையை இந்த ஆய்விற்காக என் முழு மனதுடனும், யாருடைய கட்டாயபடுத்தலுமின்றி என் சொந்த விருப்புடன் கலந்து கொள்ள சம்மதம் தெரிவிக்கிறேன்.

தானம் செய்பவரின் கையொப்பம் புலனாய்வாளர் கையொப்பம்

தானம் செய்பவரின் பெயர் :

சாட்சியின் கையொப்பம்

தேதி :

<u>प्रोजेक्ट का नाम:</u> वी (Wii) गेम का प्रयोग - सैरीबरल पाल्सी के बच्चो के पुर्नवास (Rehabilitation) के लिए।

<u>मुख्य शोधकर्ता</u> - डा० जैन एलिज़ाबेथ साजन

<u>विभाग</u> :- फीजिकल मैडीसिन और रीहैबीलीटेशन (PMR)

सैरीबरल पाल्सी के बच्चो में संतुलन और चाल के नियंत्रण में कमी पाई जाती है। इसकी वजह से बच्चे रोज़मर्रा की गतिविधियों को पूरी तरह नहीं कर पाते। निन्टेन्डो वी (Nintendo Wii) गेम पर बच्चा काल्पनिक वातावरण में गेम खेलता है। हमारा विभाग इस शोध के द्वारा यह पता लगाना चाहता है कि वी (Wii) गेम के प्रयोग से Cerebral Palsy के बच्चों के इलाज में कुछ फायदा होता है या नहीं। यदि आप इस शोध में भाग लेते है तो हो सकता है कि आपके बच्चे को प्रतिदिन 40-45 मिनट तक वी (Wii) गेम पर खेलने को कहा जा सकता है। इस दौरान आपके बच्चे को दी जाने वाली पुर्नवास चिकित्सा जारी रहेगी। शोध के पहले और बाद में, आपके बच्चे का संतुलन, चाल और आँखो की जाँच की जाएगी।

इस शोध से आपके बच्चे की सेहत पर कोई बुरा प्रभाव पड़ने की संभावना नहीं है। आपकी पूरी वैयक्तिक जानकारी गुप्त रखी जाएगी। यदि आप इस शोध में भाग न लेना चाहे, तो आप ऐसा करने के लिए मुक्त है। आप कभी भी अपने बच्चे को इस शोध के प्रोजेक्ट से निकाल सकते है। ऐसा करने पर आपके बच्चे के चल रहे इलाज पर कोई प्रभाव नहीं पड़ेगा।

यदि आप किसी प्रकार की और जानकारी चाहते हो, तो आप ~~मुझे~~ मुझ से सम्पर्क कर सकते है—

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सहमति पत्र

प्रोजेक्ट का नाम-
निन्टैन्डो वी (Nintendo Wii) गेम का प्रयोग, सैरीबरल पाल्सी (Cerebral Palsy) के ~~बच्च~~ बच्चो के उपचार

प्रमुख जाँचकर्ता - डा० जैन एलिजाबेथ साजन

विभाग - फीज़िकल मैडिसिन और रीहैबीलीटेशन
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ने मुझे इस प्रोजेक्ट के बारे में पूरी तरह से समझा दिया है। मुझे जो भी बताया गया है, मैं वो पूरी तरह से समझ गया हूँ और वह निम्नलिखित है —

1. अगर मैं इस प्रोजेक्ट में अपने बच्चे के भाग लेने की इजाज़त देता हूँ, तो हो सकता है कि उसे वी (Wii) गेम पर 40-45 मिनट प्रतिदिन और एक सप्ताह में छः दिन खेलने को कहा जाए। इसकी भी संभावना है कि मेरे बच्चे को गेम पर खेलने को न कहा जाए।
2. वी (Wii) गेम पर खेलने से मेरे बच्चे की सेहत पर किसी प्रकार का कोई दुष्प्रभाव पड़ने की संभावना नहीं है।
3. मुझे पूरा अधिकार है कि मैं इस प्रोजेक्ट में भाग लेने से मना भी कर सकता हूँ। इस प्रोजेक्ट की अवधि के दौरान, मैं कभी भी अपने बच्चे को इस प्रोजेक्ट से निकाल सकता हूँ और ऐसा करने पर मुझे कोई सफाई देने की आवश्यकता नही है। इस प्रकार की किसी भी सूरत में, मेरे बच्चे के इस हस्पताल में चल रहे इलाज पर कोई असर नही पड़ेगा और उसका इलाज उसी प्रकार चलता रहेगा।

P.T.O.

यह सब जानते हुए, मैं ~~अपने~~ सहमति प्रदान करता हूँ कि मेरा बच्चा इस प्रोजेक्ट में भाग ले सकता है। यह सहमति मैं अपनी इच्छा से और बिना किसी भी प्रकार के दबाव में, दे रहा हूँ।

(माता/पिता के हस्ताक्षर) जाँचकर्ता के हस्ताक्षर

नाम-

गवाह के हस्ताक्षर

तिथि-

यदि आपको कभी भी भी कोई भी प्रश्न पूछना है, तो आप मुझे सम्पर्क कर सकते हैं-

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সূচিত অনুমোদন পত্র

গবেষণার বিষয়: সেরিব্রাল পালসীতে আক্রান্ত শিশুদের নিনটেনডো (NINTENDO Wii™) গেমীং (খেলার) দ্বারা পুনর্বাসন।

গবেষক: ডা: জেন এলিজাবেথ।
বিভাগ: দৈহিক চিকিৎসা ও পুনর্বাসন (পি এম আর)

____________________ আমাকে গবেষণার বিষয়বস্তু বুঝিয়েছেন। আমাকে সব বলা হয়েছে এবং নিম্নলিখিত তথ্যগুলি আমি পরিষ্কার ভাবে বুঝেছি।

১. গবেষণায় অংশগ্রহণে আগ্রহী হলে, আমার সন্তানকে খেলাটি খেলতে দেওয়া হতে পারে, নাও পারে। খেলার অনুমতি পেলে আমার সন্তানকে সপ্তাহে ৬ দিন, প্রতিদিন ৩০ মিঃ, ৩ সপ্তাহের ধরে খেলতে হবে। (মোট ১৮ টি সেশন)।

২. এই NINTENDO Wii™ খেলায় আমার সন্তানের অদূর ভবিষ্যতে সম্ভবত কোনো বিরূপ প্রতিক্রিয়া হবে না।

৩. আমি এই গবেষণায় অনিচ্ছুক হলে, কোনো কারণ না দেখিয়ে আমার সন্তানকে গবেষণার অংশগ্রহণ থেকে তুলে নিতে পারি। এতে আমার সন্তানের নিয়মিত চিকিৎসায় কোনো বাধা পড়বে না।

আমি স্বেচ্ছায় আমার সন্তানের অংশগ্রহণের অনুমতি দিচ্ছি। এতে গবেষকের আমার ওপর কোনো রকমের চাপ সৃষ্টি করে নি।

	স্বাক্ষীর সহি
অভিভাবকের সহি	
অভিভাবকের নাম	স্বাক্ষীর নাম

অতিরিক্ত সূচনার জন্য যোগাযোগ করুন;
ডা: জেন এলিজাবেথ
দৈহিক চিকিৎসা ও পুনর্বাসন বিভাগ
ক্রিশ্চিয়ান মেডিকেল কলেজ, বাগায়াম, ভেলোর
দূরভাষ: +৯১- ৯৫০০৪-৬৪০৫২
ই-মেল:

রোগীদের সূচনাপত্র (তথ্যপত্র)

গবেষণার বিষয়: সেরিব্রাল পালসিতে আক্রান্ত শিশুদের NINTENDO Wii™ (নিনটেন্ডো) গেমিং এর সাহায্যে পুনর্বাসন।

গবেষক : ডা: জেন এলিসাবেথ।

বিভাগ : দৈহিক চিকিৎসা ও পুনর্বাসন। সিএমসি ভেলোর।

সেরিব্রাল পালসিতে দেহের অনান্য গঠনগত সমস্যা ছাড়াও দেহের ভারসাম্য বজায় রাখার অসুবিধা হয়। এতে আক্রান্ত শিশুদের নিত্য-নৈমিত্তিক জীবনধারনেও মুস্কিল হয়। NINTENDO Wii™ একটি বানিজ্যিক ভাবে লভ্য গেমিং কনসোল (GAMING CONSOLE) যার দ্বারা এজেন খেলোয়াড় কম্পুটার উদ্ভাবিত অবাস্তব জগতে (VIRTUAL REALITY) খেলার সুযোগ পান। এই গবেষণায় এই খেলার দ্বারা আক্রান্ত শিশুদের কোনো উন্নতি হয় কিনা, তা দেখা হবে।

আপনি যদি চান তা হলে আপনার সন্তান এই গবেষণায় অংশগ্রহণ করতে পারে। তবে এই খেলাটি খেলতে দেওয়া সুযোগ দেওয়া বা না দেওয়া গবেষক বিবরণ সংক্রান্ত ভাবে, (Statistics) এর সাহায্যে করবেন। আপনার সন্তানকে সপ্তাহে ৬ দিন, প্রতিদিন ৩০ মিঃ - ৩ সপ্তাহের জন্যে এই গবেষণায় অংশগ্রহণ করতে হবে (সর্বত ১৮ টি সেশন)। আপনার সন্তান তার প্রাপ্য নিয়মিত চিকিৎসাগুলিও পাবে। খেলার আগে এবং পরে দৈহিক ভারসাম্য, গতিশীলতা এবং দৃষ্টির মূল্যায়ন করা হবে। এই খেলার পর ভারসাম্য, গতিশীলতা এবং দৃষ্টির কোনো উন্নতি হয় কিনা, তা গবেষণার মূল বিষয়।

এই গবেষণার অংশগ্রহনে আপনার সন্তানের অদূর ভবিষ্যতে কোনো বিরূপ প্রতিক্রিয়ার সম্ভাব্য কোনো কারন নেই। আপনার সন্তানের তথ্য গোপনীয় রাখা হবে। যদি অংশগ্রহনে অনিচ্ছুক হন, তাহলে তা করবার পূর্ণ অধিকার আপনার আছে।

যদি কোনো অংশগ্রহণের পরেও, আপনি এই গবেষণায় থেকে বিরত থাকতে চান, তা করার ও পূর্ণ অধিকার আপনার আছে। এতে আপনাকে কোনো কারন প্রদর্শন করতে হবে না। এই সাথে এই সংপৃক্তয় আপনার মনোযোগে চিকিৎসায় কোনো হের-ফের হবে না।

অতিরিক্ত তথ্য এবং চাইলে NINTENDO Wii TM গেমিং এর তথ্যের জন্যে নিম্নলিখিত ঠিকানায় যোগাযোগ করুন

ডা: জেন এলিজাবেথ
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(ই-মেল)

രോഗി വിവരണ പത്രിക.

പഠനവിഷയം: CEREBRAL PALSY ഉള്ള കുട്ടികളുടെ പുനരധിവാസത്തിനായി Nintendo Wii കളികൾക്കുള്ള പ്രസക്തി.

മുഖ്യ ഗവേഷക: Dr. ജെയിൻ എലിസബത്ത് സാജൻ

ഡിപ്പാർട്ട്മെന്റ്: PHYSICAL MEDICINE AND REHABILITATION (PMR), CMC VELLORE.

CEREBRAL PALSY ഉള്ള കുട്ടികളിൽ വളർച്ചയുടെ വിവിധ ഘട്ടങ്ങളിലുള്ള ബുദ്ധിമുട്ടുകൾക്ക് പുറമെ ഒരു പ്രധാന പ്രശ്നം (Balance) ബാലൻസിന്റെയും POSTURE CONTROL-ന്റെയും ബുദ്ധിമുട്ടാണ്. ഇത് പ്രധാനമായും കുട്ടിയുടെ സ്വന്തമായി ദിനചര്യ ചെയ്യുന്നതിനെ ബാധിക്കുന്നു. Nintendo Wii എന്നത് കമ്പോളത്തിൽ വാങ്ങാവുന്ന ഒരു കളിയാണ് (Game). ഇതിൽ കളിക്കാർക്ക് ഒരു സാങ്കല്പിക പരിസ്ഥിതിയിൽ കളികൾ കളിയ്ക്കാം. CMC വെല്ലൂർ - PMR ഡിപ്പാർട്ട്മെന്റിൽ ഇത്തരത്തിലുള്ള കളികൾ CEREBRAL PALSY ഉള്ള കുട്ടികൾക്ക് പ്രയോജനപ്പെടുമോ എന്നറിയുന്നതിന് ഒരു പഠനം നടത്തുന്നുണ്ട്.

നിങ്ങൾക്ക് ഇതിന് സമ്മതമാണെങ്കിൽ നിങ്ങളുടെ കുട്ടിയെ Nintendo Wii games ദിവസം 45-60 മിനിറ്റ്, ആഴ്ചയിൽ 6 ദിവസം അങ്ങനെ 3 ആഴ്ച നിങ്ങളുടെ കുട്ടിയെ ചിലപ്പോൾ പങ്കെടുപ്പിക്കേണ്ടി വരും. ഇതിനു പുറമെ സാധാരണയായി കുട്ടിക്ക് ലഭിക്കുന്ന ചികിത്സ (therapy) മുടങ്ങാതെ ലഭിക്കുന്നതായിരിക്കും.

ഈ കളി തുടങ്ങുന്നതിന് മുൻപും പൂർത്തിയായതിന് ശേഷവും കുട്ടിയുടെ ബാലൻസ്, ചലനം (mobility) ദൃശ്യ അവബോധം (visual perception) അളക്കുന്നതിന് ചില പരിശോധന ചെയ്യുന്നതായിരിക്കും. ഈ പഠനത്തിലൂടെ wii games cerebral palsy ഉള്ള കുട്ടികളുടെ Balance & posture (ബാലൻസ്), mobility (ചലനം), ദൃശ്യ അവബോധം വർദ്ധിക്കുവാനുള്ള സാധ്യതയുണ്ടോ എന്ന് കണ്ടുപിടിക്കാൻ ശ്രമിക്കുന്നതായിരിക്കും.

ഈ പഠനത്തിൽ പങ്കെടുക്കുന്നത് കൊണ്ട് നിങ്ങളുടെ കുഞ്ഞിന് ആരോഗ്യത്തിന് ഹാനികരമായി ഒന്നും സംഭവിക്കാൻ സാധ്യതയില്ല. നിങ്ങളുടെ സ്വകാര്യ വിവരങ്ങൾ ഞങ്ങൾ വളരെ രഹസ്യമായി തന്നെ വയ്ക്കും. നിങ്ങളുടെ കുഞ്ഞിനെ ഇതിൽ ഉൾപ്പെടുത്താൻ നിങ്ങൾ താത്പര്യപ്പെടുന്നില്ലെങ്കിൽ നിങ്ങൾക്ക് അത് തുറന്നു പറയാം. ഇതിൽ ഉൾപ്പെടുത്തി കഴിഞ്ഞതിന് ശേഷവും ഏത് ഘട്ടത്തിലും നിങ്ങൾക്ക് നിങ്ങളുടെ കുട്ടിയെ യാതൊരു വിശദീകരണവും കൂടാതെ പിൻമാറുവാൻ പൂർണ്ണസ്വാതന്ത്ര്യമുണ്ടായിരിക്കുന്നതാണ്. അത് നിങ്ങളുടെ കുഞ്ഞിന്റെ ഈ ആശുപത്രിയിലെ പരിചരണത്തെ ഒരു തരത്തിലും ബാധിക്കയില്ല

നിങ്ങൾക്ക് ഇതിനെ കുറിച്ച് കൂടുതൽ വിവരങ്ങൾ ആവശ്യമെങ്കിൽ താഴെ കാണുന്ന അഡ്രസ്സിൽ ബന്ധപ്പെടുക

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INFORMED CONSENT

പഠനവിഷയം: CEREBRAL PALSY ഉള്ള കുട്ടികളുടെ പുനരധിവാസത്തിനായി Nintendo Wii കളികൾക്കുള്ള പ്രസക്തി

മുഖ്യ ഗവേഷക: Dr. ജെയിൻ എലിസബത്ത് സാജൻ
ഡിപ്പാർട്ട്മെന്റ്: PHYSICAL MEDICINE AND REHABILITATION (PMR), CMC VELLORE.

ഈ പഠനത്തിന്റെ വിശദാംശങ്ങൾ വ്യക്തമായി പറഞ്ഞു തന്നിട്ടുണ്ട്. അത് എനിയ്ക്ക് പൂർണ്ണമായി മനസ്സിലായിട്ടുണ്ട്.

1. ഞാൻ എന്റെ കുഞ്ഞിനെ ഈ ചികിത്സാ-പഠനത്തിൽ ഉൾപ്പെടുത്താൻ സമ്മതിച്ചാൽ എന്റെ കുഞ്ഞിന് ഈ Nintendo Wii കളികൾ 45-65 min/day, ആഴ്ചയിൽ - 6 ദിവസം, അങ്ങനെ 3 ആഴ്ച പ്രോഗ്രാമിൽ (program) ഉൾപ്പെടുത്തുകയോ ഉൾപ്പെടുത്താതിരിക്കുകയോ ചെയ്യും.
2. ഇത് കളിക്കുന്നത് മൂലം എന്റെ കുഞ്ഞിന് ദോഷകരമായി ഒന്നും സംഭവിക്കുന്നതിനുള്ള സാധ്യത കാണുന്നില്ല.
3. എനിയ്ക്ക് ഇതിനു വേണ്ടി സമ്മതം കൊടുക്കുകയോ കൊടുക്കാതിരിക്കുകയോ, കൊടുത്തതിനു ശേഷം ഏത് ഘട്ടത്തിലും പിൻമാറുകയോ ചെയ്യാം.

അങ്ങനെ ചെയ്യുന്നത് മൂലം എന്റെ കുഞ്ഞിന്റെ ഈ ആശുപത്രിയിലെ പരിചരണം ഒരു തരത്തിലും ദോഷമായി ബാധിക്കുന്നതല്ല.
ഞാൻ സ്വതന്ത്രമായി ഇതിനു വേണ്ടി സമ്മതം കൊടുക്കുന്നു. ഇങ്ങനെ ചെയ്യുന്നതിന് എന്റെ മേൽ ഈ ചികിത്സാപഠനത്തിൽ ഉൾപ്പെട്ടവരാരും സമ്മർദ്ദം ചെലുത്തിയിട്ടില്ല.

മുഖ്യഗവേഷകയുടെ ഒപ്പ്.

രക്ഷിതാവിന്റെ ഒപ്പ്

രക്ഷിതാവിന്റെ പേര്.

സാക്ഷിയുടെ ഒപ്പ്

സാക്ഷിയുടെ പേര്

തിയ്യതി:

നിങ്ങൾക്ക് ഇതിനെക്കുറിച്ച് കൂടുതൽ വിവരങ്ങൾ ആവശ്യമെങ്കിൽ താഴെ കാണുന്ന വിലാസത്തിൽ ബന്ധപ്പെടുക.

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రోగి సమాచార పత్రము

పరిశీలన యొక్క పేరు: సెరిబ్రల్ పాల్సి ఉన్న పిల్లల పునర్వవస్థీకరణకు నిన్టెందో వయ్ అనే ఆట వల్ల కలిగే ప్రయోజనము
ప్రధాన పరిశోధకులు: డాక్టర్. జేన్ ఎలిజబెత్ సుసాన్
పరిశీలన సాఖ: ఫిసికాల్ మెడిసిన్ మరియు రెహబిలిటేషన్ సాఖ

సెరిబ్రల్ పాల్సి వలన నిలకడగా ఉండలేక పోవడం మరియు ఎదుగదల సమస్యలు ఉందును. దీని వలన పిల్లలకి రోజు చేసుకునే పనులలో కష్టం కలుగుతుంది. ఈ నిన్టెందో వయ్ ఆట వ్యాపారస్తుల వద్ద లబించును. దీనిని ఉపయోగించుకుని కృత్రిమంగ ఏర్పాటు చేసిన ఆరోగ్యవంతమైన పరిసరాల్లో ఆటలు ఆడవచ్చును. కావున క్రిస్టియన్ మెడికల్ కాలేజీ లోని ఫిసికాల్ మెడిసిన్ మరియు రెహబిలిటేషన్ సాఖ కృత్రిమంగ ఏర్పాటు చేసిన ఆరోగ్యవంతమైన పరిసరాల్లో ఆటలు ఆడటం (నిన్టెందో వయ్ అనే ఆట) వల్ల సెరిబ్రల్ పాల్సి ఉన్న పిల్లలకు ఉపయోగం వుంటుందా లేదా అని పరిశోధన చేస్తున్నారు. మీరు కనక మీ బిడ్డని ఈ పరిశోధనలో పాల్గొనుటకు అంగీకరిస్తే, మీ బిడ్డని ఈ నిన్టెందో వయ్ ఆటని ఆడమని అడగవచ్చును. ఒకవేళ ఆదినచో రోజుకి 45-60 నిముషాలు, వారానికి 6 రోజులు, ఇలా 3 వారలు (మొత్తం 18 సార్లు) ఆడాలి. మీ బిడ్డకు ఎప్పటిలాగే పునర్వవస్థీకరణ వైద్యము మా శాఖ వద్ద లభించును. ప్రతిసారి ఈ ఆట ఆడిన తరువాత చలన శక్తికి, సమతుల్యముగా ఉండుటకు మరియు చూసి అర్థం చేసుకోనుటకు సంబంధించిన నాణ్యమైన పరిక్షలు చేస్తాము. ఇలా పరిసిలించటం వలన ఈ నిన్టెందో వయ్ ఆట సెరిబ్రల్ పాల్సి వల్ల బాధపడే పిల్లల యొక్క సమతుల్యము, చురుకుదనము, చలన శక్తి, మరియు చూసి అర్థం చేసుకోవటం వంటి అంశాలు మేరుగుపదతాయో లేదో తెలుసుకోవచ్చును.
ఎటువైపునుంచి చూసినా ఈ పరిశోధనలో పాల్గొనటం వలన మీ బిడ్డకు ఎటువంటి ఇబ్బంది లేదా కష్టం కలుగదు. మీ వద్ద నుంచి తీసుకున్న వ్యక్తిగత సమాచారం చాలా గోప్యంగా ఉంచబడుతుంది. ఒకవేళ మీ బిడ్డ ఈ పరిశోధనలో పాల్గొనడం మీకు ఇష్టం లేకపోతే, ఈ విషయాన్ని మీరు స్వతంత్రంగా చెప్పవచ్చు. ఈ పరిశోధన జరుగుతున్నప్పుడు ఎప్పుడైనా సరే మీ బిడ్డని ఈ పరిసోధనలోనుంచి ఎటువంటి కారణాలు చెప్పకుండానే మాన్పించవచ్చు. ఇలా చేయటం వలన మా ఆస్పత్రిలో మీ బిడ్డకు ఇచ్చే చికిత్సలో ఎతివంటి మార్పు వుండదు.

మీకు ఇంకేమైనా సందేహములు వుంటే మమ్ములను సంప్రదిన్చగలరు. సంప్రదించవలసిన చిరునామా క్రింద వున్నది. మీరు కోరిన యెడల నిన్టెందో వయ్ ఆట గురించి మరియు నిర్థారణ పరిక్షల గురించి వివరములు కావలసిన యెడల మీ కోరిక మేరకు అందచేయపడును.

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వాస్తవాలు తెలిపే ఆమోదపు పత్రము

పరిశీలన యొక్క పేరు: సెరిబ్రల్ పాల్సీ ఉన్న పిల్లల పునర్వవస్థీకరణకు నిన్తెందో వయ్ అనే ఆట వల్ల కలిగే ప్రయోజనము.

ప్రధాన పరిశోధకులు: డాక్టర్. జేన్ ఎలిజబెత్ సుసాన్.

పరిశీలన సాఖ: ఫిసికాల్ మెడిసిన్ మరియు రెహబిలిటేషన్ సాఖ (పి. ఏం. ఆర్), క్రిస్టియన్ మెడికల్ కాలేజీ, వెల్లూరు.

___________________ అనువారు నాకు ఈ పరిశోధన గురించి పూర్తిగా వివరించారు. వారు చెప్పిన విషయములు నాకు అర్ధం అయినవి. వారు చెప్పినవి ఈ విధముగా వున్నాయి...

1) నేను నా బిడ్డని ఈ పరిశోధనలో పాల్గొనుటకు ఆమోదిన్చినచో, వారు చెప్పినట్టు ఈ నిన్తెందో వయ్ ఆటని రోజుకి 45-60 నిముషాలు, వారానికి 6 రోజులు, ఇలా 3 వారలు (మొత్తం 18 సార్లు) తప్పకుండ ఆడవలసిన అవసరం లేదు.

2) నిన్తెందో వయ్ ఆటని ఆడటం వలన బిడ్డ ఆరోగ్యానికి ఎటువంటి హాని జరుగదు.

3) నా బిడ్డ ఈ పరిశోధనలో పల్గోనచేయుతకు నాకు స్వతంత్రం వుంది. ఈ పరిశోధన మధ్యలో కూడా నా బిడ్డను మాన్పించటానికి నాకు స్వతంత్రం వుంది. నా నిర్ణయం నా బిడ్డకి ఈ ఆస్పత్రిలో జరిగే చికిత్సపై ఎటువంటి ప్రభావం చూపదు.

దాత సంతకము

పరిసోధకుడి సంతకము

దాత పేరు:

సాక్షి సంతకము

తేది:

మీకు ఏమైనా వివరాలు కావలసిన, ఈ క్రింది చిరునామా వ్యక్తిని సంప్రదించగలరు...

డాక్టర్. జేన్ ఎలిజబెత్ సుసాన్

ఫిసికాల్ మెడిసిన్ మరియు రెహబిలిటేషన్ సాఖ,

క్రిస్టియన్ మెడికల్ కాలేజీ,

బాగాయం,

వెల్లూరు, తమిళనాడు - 632002.

ఫోన్: +91 – 9500834052 (మొబైల్/ సెల్)

ఇ-మెయిల్: janesajan@gmail.com

Assent Form

My name is Dr. Jane Elizabeth Sajan. I am working in the department where you have come for your treatment (department of PMR). I am doing a study where I am trying to find out if playing a game called Nintendo Wii is beneficial for children with cerebral palsy. Since you have this condition, I would like to request you to be part of this study.

Your parents have said it's OK for you to be in the study. If you would like to be part of the study, you will be asked to play Wii games for an hour every day, except Sunday, for 3 weeks. This will be in addition to the routine treatment you will get in the hospital. You will need to undergo a few tests before and after you have completed the study.

There is a small risk that you may fall and injure yourself while playing Wii games. However, there will always be somebody to supervise you while you are playing so that you don't get hurt.

You can say that you don't want to be part of the study at any time. You will not have to give any reason if you do so. The care that you get in hospital will remain the same whether you decide to be part of the study or not.

You can ask me anytime if you have any questions about the study or if you decide you don't want to be in the study any more.

I will give you a copy of this form in case you want to read it later or show it to your parents.

Agreement

I was explained about the study. I was allowed to choose whether I wanted to be part of the study or not. I also had an opportunity to clarify my doubts regarding the study. I am willing to be part of the study and give my assent for the same.

____

Signature of Study Participant Date

I have discussed this study with _______ using language which is understandable and appropriate for the participant. I believe that I have fully informed him/her of the nature of the study and its possible risks and benefits. I believe the participant understood this explanation and assent to participate in this study.

____

Signature of Researcher Date

INFORMED CONSENT FOR TAKING PATIENT`S PHOTOGRAPH

Miss Sabrina CMC Hospital no: 638206F with cerebral palsy is admitted for rehab in the dept. of PMR, CMC, Vellore. Sabrina and her parents were explained in their own language regarding taking photographs related to her therapy, in the department of PMR for my thesis work. It was also explained to them that this photographs will appear in the thesis work. However, all precautions will be taken to conceal the child's identity. They have understood and have given their informed consent for the same.

Date: 22/9/14

Signature of parent: - Mrs. Fathima Akthar (Sabrina's mother)

Jane

Explained by Dr. Jane Elizabeth Sajan

PG Registrar.

DEPT. OF PHYSICAL MEDICINE & REHABILITATION * CHRISTIAN MEDICAL COLLEGE * VELLORE-632004

RAGHUL 991786D 6 M
C PMR1 RI Ward 930666I CHILD H

INFORMED CONSENT FOR TAKING PATIENT`S PHOTOGRAPH

Mr. Raghul`s parents and Raghul were explained in their own language regarding taking photographs related to his therapy, in the department of PMR for my thesis work. It was also explained to them that this photographs will appear in the thesis work. However, all precautions will be taken to conceal the child's identity. They have understood and have given their informed consent for the same.

Date: 8/9/14

Signature of parent:

M·சரண்யா (Mrs. M. Saranya)
Raghul's mother

Explained by Dr. Jane Elizabeth Sajan Jane

PG Registrar.

DEPT. OF PHYSICAL MEDICINE & REHABILITATION * CHRISTIAN MEDICAL COLLEGE * VELLORE-632004 *

Box and Blocks Test Instructions

General Information (derived from Mathiowetz et al, 1985):

- The patient is allowed a 15-second trial period prior to testing
- Immediately before testing begins, the patient should place his/her hands on the sides of the box
- When testing begins, the patient should grasp one block at a time with the dominant hand, transport the block over the partition, and release it into the opposite compartment
- The patient should continue doing this for one minute
- The procedure should then be repeated with the nondominant hand
- After testing, the examiner should count the blocks
- If a patient transports two or more blocks at the same time, this should be noted and the number subtracted from the total
- No penalty should be made if the subjects transported any blocks across the partition and the blocks bounced from the box to the floor or table

Set-up:

- A test box with 150 blocks and a partition in the middle is placed lengthwise along the edge of a standard-height table
- The patient should be seated on a standard height chair facing the box
- 150 blocks should be in the compartment of the test box on the side of the patient's dominant hand
- The examiner should face the patient so she or he could view the blocks being transported

Patient Instructions (derived from Mathiowetz et al, 1985):

"I want to see how quickly you can pick up one block at a time with your right (or left) hand [point to the hand]. Carry it to the other side of the box and drop it. Make sure your fingertips cross the partition. Watch me while I show you how."

Transport three cubes over the partition in the same direction you want the patient to move them. After a demonstration say the following:

"If you pick up two blocks at a time, they will count as one. If you drop one on the floor or table after you have carried it across, it will still be counted, so do not waste time picking it up. If you toss the blocks without your fingertips crossing the partition, they will not be counted. Before you start, you will have a chance to practice for 15 seconds. Do you have any questions?"

“Place your hands on the sides of the box. When it is time to start, I will say ready and then go.”

Trial period: Start the stop watch at the word go. When 15 seconds has passed, say "stop." If mistakes are made during the practice period, correct them before the actual testing begins.

On completion of the practice period, transport the cubes to the original compartment.

Continued with the following directions:

“This will be the actual test. The instructions are the same. Work as quickly as you can. Ready.” [Wait 3 seconds]
“Go.”
“Stop.” [After 1 minute, count the blocks and record as described above]

“Now you are to do the same thing with your left (or right) hand. First you can practice. Put your hands on the sides of the box as before. Pick up one block at a time with your hand, and drop it on the other side of the box.”

“Ready.” [Wait 3 seconds]
“Go.”
“Stop.” [After 15 seconds]

Return the transported blocks to the compartment as described above.

“This will be the actual test. The instructions are the same. Work as quickly as you can.”

“Ready.” [Wait 3 seconds]
“Go.”
“Stop.” [After 1 minute, count the blocks and record as described above]

Scoring

The score is the number of blocks carried from one compartment to the other in one minute. Score each hand separately.

Box and Blocks Testing Form

Name: ____

Dominant Hand (circle one): Right Left

Number of blocks transported in one minute:

Date: ________ Dominant Hand: __________ Non-Dominant Hand: _______

Date: ________ Dominant Hand: __________ Non-Dominant Hand: _______

Date: ________ Dominant Hand: __________ Non-Dominant Hand: _______

Date: ________ Dominant Hand: __________ Non-Dominant Hand: _______

Reference:

Mathiowetz, V., G. Volland, et al. (1985). "Adult norms for the Box and Block Test of manual dexterity." Am J Occup Ther **39**(3160243): 386-391.

A

PEDIATRIC BALANCE SCALE

Name:	______________________	Date:	____________
Location:	______________________	Examiner:	____________

Item Description	Score *0 - 4*	Seconds *optional*
1. Sitting to standing	______	
2. Standing to sitting	______	
3. Transfers	______	
4. Standing unsupported	______	______
5. Sitting unsupported	______	______
6. Standing with eyes closed	______	______
7. Standing with feet together	______	______
8. Standing with one foot in front	______	______
9. Standing on one foot	______	______
10. Turning 360 degrees	______	______
11. Turning to look behind	______	
12. Retrieving object from floor	______	
13. Placing alternate foot on stool	______	______
14. Reaching forward with outstretched arm	______	
Total Test Score	______	

General Instructions

1. Demonstrate each task and give instructions as written. A child may receive a practice trial on each item. If the child is unable to complete the task based on their ability to understand the directions, a second practice trial may be given. Verbal and visual directions may be clarified through the use of physical prompts.

2. Each item should be scored utilizing the 0 to 4 scale. Multiple trials are allowed on many of the items. The child's performance should be scored based upon the lowest criteria, which describes the child's best performance. If on the first trial a child receives the maximal score of 4, additional trials need not be administered. Several items require the child to maintain a given position for a specific time. Progressively, more points are deducted if the time or distance requirements are not met; if the subject's performance warrants supervision; or if the subject touches an external support or receives assistance from the examiner. Subjects should understand that they must maintain their balance while attempting the tasks. The choice, of which leg stand on or how far to reach, is left to the subject. Poor judgement will adversely influence the performance and the scoring. In addition to scoring items 4, 5, 6, 7, 8, 9, 10, and 13, the examiner may choose to record the exact time in seconds.

Figure. No caption available.

B

Equipment

The Pediatric Balance Scale was designed to require minimal use of specialized equipment. The following is a complete list of items required for administration of this tool:

adjustable height bench
chair with back support and arm rests
stopwatch or watch with a second hand
masking tape - 1inch wide
a step stool 6 inches in height
chalkboard eraser
ruler or yardstick
a small level

The following items are optional and may be helpful during test administration:

2 child-size footprints
blindfold
a brightly colored object of at least two inches in size
flash cards
2 inches of adhesive-backed hook Velcro
Two 1 foot strips of loop Velcro

****

1. **Sitting To Standing**

* ***Special instruction***: *Items #1 and #2 may be tested simultaneously if, in the determination of the examiner, it will facilitate the best performance of the child.*

INSTRUCTIONS: **Child is asked to "Hold arms up and stand up."** The child is allowed to select the position of his/her arms.

EQUIPMENT: A bench of appropriate height to allow the child's feet to rest supported on the floor with the hips and knees maintained in 90 degrees of flexion.

Best Of Three Trials

( ) 4 able to stand without using hands and stabilize independently
( ) 3 able to stand independently using hands
( ) 2 able to stand using hands after several tries
( ) 1 needs minimal assist to stand or to stabilize
( ) 0 needs moderate or maximal assist to stand

Figure. No caption available.

c

2. **Standing To Sitting**

** **<u>Special instruction</u>**: Items #1 and #2 may be tested simultaneously if, in the determination of the examiner, it will facilitate the best performance of the child.*

<u>INSTRUCTIONS</u>: **Child is asked to sit down slowly, without use of hands.** The child is allowed to select the position of his/her arms.

<u>EQUIPMENT</u>: A bench of appropriate height to allow the child's feet to rest supported on the floor with the hips and knees maintained in 90 degrees of flexion.

<u>Best Of Three Trials</u>

( ) 4 sits safely with minimal use of hands
( ) 3 controls descent by using hands
( ) 2 uses back of legs against chair to control descent
( ) 1 sits independently, but has uncontrolled descent
( ) 0 needs assistance to sit

3. **Transfers**

<u>INSTRUCTIONS</u>: Arrange chair(s) for a stand pivot transfer, touching at a forty-five degree angle. **Ask the child to transfer one way toward a seat with armrests and one way toward a seat without armrests.**

<u>Equipment</u>: Two chairs, or one chair and one bench. One seating surface must have armrests. One chair/bench should be of standard adult size and the other should be of an appropriate height to allow the child to conformably sit with feet supported on the floor and ninety degrees of hip and knee flexion.

<u>Best Of Three Trials</u>

( ) 4 able to transfer safely with minor use of hands
( ) 3 able to transfer safely; definite need of hands
( ) 2 able to transfer with verbal cueing and/or supervision (spotting)
( ) 1 needs one person to assist
( ) 0 needs two people to assist or supervise (close guard) to be safe

Figure. No caption available.

D

4. **Standing Unsupported**

INSTRUCTIONS: **The child is asked to stand for 30 SECONDS without holding on or moving his/her feet.** A taped line or footprints may be placed on the floor to help the child maintain a stationary foot position. The child may be engaged in non-stressful conversation to maintain attention span for thirty seconds. Weight shifting and equilibrium responses in feet are acceptable; movement of the foot in space (off the support surface) indicates end of the timed trial.

EQUIPMENT: a stop watch or watch with a second hand
a twelve inch long masking tape line or two footprints placed shoulder width apart

( ) 4 able to stand safely 30 SECONDS
( ) 3 able to stand 30 SECONDS with supervision (spotting)
( ) 2 able to stand 15 SECONDS unsupported
( ) 1 needs several tries to stand 10 SECONDS unsupported
( ) 0 unable to stand 10 SECONDS unassisted

_____Time in seconds

Special Instructions: If a subject is able to stand 30 SECONDS unsupported, score full points for sitting unsupported. Proceed to item #6

5. **Sitting With Back Unsupported And Feet Supported On The Floor**

INSTRUCTIONS: **Please sit with arms folded on your chest for 30 SECONDS**. Child may be engaged in non-stressful conversation to maintain attention span for thirty seconds. Time should be stopped if protective reactions are observed in trunk or upper extremities.

EQUIPMENT: a stop watch or watch with a second hand
a bench of appropriate height to allow the feet to rest supported on the floor with the hips and knees maintained in ninety degrees of flexion.

( ) 4 able to sit safely and securely 30 SECONDS
( ) 3 able to sit 30 SECONDS under supervision (spotting) or may require definite use of upper extremities to maintain sitting position
( ) 2 able to sit 15 SECONDS
( ) 1 able to sit 10 SECONDS
( ) 0 unable to sit 10 SECONDS without support

_____ Time in seconds

Figure. No caption available.

E

6. **Standing Unsupported With Eyes Closed**

INSTRUCTIONS: The child is asked to stand still with feet shoulder width apart and close his/her eyes for ten seconds. **Direction: "When I say close your eyes, I want you to stand still, close your eyes, and keep them closed until I say open."** If necessary, a blindfold may be used. Weight shifting and equilibrium responses in the feet are acceptable; movement of the foot in space (off the support surface) indicates end of timed trial. A taped line or footprints may be placed on the floor to help the child maintain a stationary foot position.

EQUIPMENT: a stop watch or watch with a second hand
a twelve-inch long masking tape line or two footprints placed shoulder width apart
blindfold

Best Of 3 Trials,

( ) 4 able to stand 10 seconds safely
( ) 3 able to stand 10 seconds with supervision (spotting)
( ) 2 able to stand 3 seconds
( ) 1 unable to keep eyes closed 3 seconds but stays steady
( ) 0 needs help to keep from falling

_____ **Time in seconds**

7. **Standing Unsupported With Feet Together**

INSTRUCTIONS: **The child is asked to place his/her feet together and stand still without holding on**. The child may be engaged in non-stressful conversation to maintain attention span for thirty seconds. Weight shifting and equilibrium responses in feet are acceptable; movement of the foot in space (off the support surface) indicates end of timed trial. A taped line or footprints may be placed on the floor to help the child maintain stationary foot position.

EQUIPMENT: a stop watch or watch with a second hand
a twelve inch long masking tape line or two footprints placed together

Best Of 3 Trials

( ) 4 able to place feet together independently and stand 30 seconds safely
( ) 3 able to place feet together independently and stand for 30 seconds with supervision (spotting)
( ) 2 able to place feet together independently but unable to hold for 30 seconds
( ) 1 needs help to attain position but able to stand 30 seconds with feet together
( ) 0 needs help to attain position and/or unable to hold for 30 seconds

_____ **Time in seconds**

Figure. No caption available.

F

8. **Standing Unsupported One Foot In Front**

INSTRUCTIONS: **The child is asked to stand with one foot in front of the other, heel to toe.** If the child cannot place feet in a tandem position (directly in front), they should be asked to step forward far enough to allow the heel of one foot to be placed ahead of the toes of the stationary foot. A taped line and/or footprints may be placed on the floor to help the child maintain a stationary foot position. In addition to a visual demonstration, a single physical prompt (assistance with placement) may be given. The child may be engaged in non-stressful conversation to maintain his/her attention span for 30 seconds. Weight shifting and/or equilibrium reactions in the feet are acceptable. Timed trials should be stopped if either foot moves in space (leaves the support surface) and/or upper extremities support is utilized.

EQUIPMENT: a stop watch or watch with a second hand
a twelve inch long masking tape line or two footprints placed heel to toe

Best Of Three Trials

( ) 4 able to place feet tandem independently and hold 30 seconds
( ) 3 able to place foot ahead of other independently and hold 30 seconds. *Note*: The length of the step must exceed the length of the stationary foot and the width of the stance should approximate the subject's normal stride width.
( ) 2 able to take small step independently and hold 30 seconds, or required assistance to place foot in front, but can stand for 30 seconds.
( ) 1 needs help to step, but can hold 15 seconds
( ) 0 loses balance while stepping or standing

_____ **Time in seconds**

9. **Standing On One Leg**

INSTRUCTIONS: **The child is asked to stand on one leg for as long as he/she is able to without holding on**. If necessary the child can be instructed to maintain his/her arms (hands) on his/her hips (waist). A taped line or footprints may be placed on the floor to help the child maintain a stationary foot position. Weight shifting and/or equilibrium reactions in the feet are acceptable. Timed trials should be stopped if the weight-bearing foot moves in space (leaves the support surface), the up limb touches the opposite leg or the support surface and/or upper extremities are utilized for support.

EQUIPMENT: a stop watch or watch with a second hand
a twelve inch long masking tape line or two footprints placed heel to toe

3 Trials Average Score

( ) 4 able to lift leg independently and hold 10 seconds
( ) 3 able to lift leg independently and hold 5 to 9 seconds
( ) 2 able to lift leg independently and hold 3 to 4 seconds
( ) 1 tries to lift leg; unable to hold 3 seconds but remains standing
( ) 0 unable to try or needs assist to prevent fall

Figure. No caption available.

G

10. **Turn 360 Degrees**

INSTRUCTIONS: **The child is asked to turn completely around in a full circle, STOP, and then turn a full circle in the other direction.**

EQUIPMENT: A stop watch or watch with a second hand

( ) 4 able to turn 360 degrees safely in 4 seconds or less each way (total of less than eight seconds)
( ) 3 able to turn 360 degrees safely in one direction only in 4 seconds or less completes turn in other direction requires more than four seconds
( ) 2 able to turn 360 degrees safely but slowly
( ) 1 needs close supervision (spotting) or constant verbal cueing
( ) 0 needs assistance while turning

_____ **Time in seconds**

11. **Turning To Look Behind Left & Right Shoulders While Standing Still**

INSTRUCTIONS: **The child is asked to stand with his/her feet still, fixed in one place. "Follow this object as I move it. Keep watching it as I move it, but don't move your feet."**

EQUIPMENT: a brightly colored object of at least two inches in size, or flash cards
a twelve inch long masking tape line or two footprints placed shoulder width apart

( ) 4 looks behind/over each shoulder; weight shifts include trunk rotation
( ) 3 looks behind/over one shoulder with trunk rotation; weight shift in the opposite direction is to the level of the shoulder; no trunk rotation
( ) 2 turns head to look to level of shoulder; no trunk rotation
( ) 1 needs supervision (spotting) when turning; the chin moves greater than half the distance to the shoulder
( ) 0 needs assist to keep from losing balance or falling; movement of the chin is less than half the distance to the shoulder

12. **Pick Up Object From The Floor From A Standing Position**

INSTRUCTIONS: **The child is asked to pick up a chalkboard eraser placed approximately the length of his/her foot in front of his/her dominant foot.** In children, where dominance is not clear, ask the child which hand they want to use and place the object in front of that foot.

EQUIPMENT: a chalkboard eraser
a taped line or footprints

( ) 4 able to pick up an eraser safely and easily
( ) 3 able to pick up eraser but needs supervision (spotting)
( ) 2 unable to pick up eraser but reaches 1 to 2 nches from eraser and keeps balance independently
( ) 1 unable to pick up eraser; needs supervision (spotting) while attempting
( ) 0 unable to try, needs assist to keep from losing balance or falling

Figure. No caption available.

H

13. **Placing Alternate Foot On Step Stool While Standing Unsupported**

INSTRUCTIONS: **The child is asked to place each foot alternately on the step stool and to continue until each foot has touched the step/stool four times.**

EQUIPMENT: a step/stool of four inches in height
a stop watch or watch with a second hand.

( ) 4 stands independently and safely and completes 8 steps in 20 seconds
( ) 3 able to stand independently and complete 8 steps >20 seconds
( ) 2 able to complete 4 steps without assistance, but requires close supervision (spotting)
( ) 1 able to complete 2 steps; needs minimal assistance
( ) 0 needs assistance to maintain balance or keep from falling, unable to try

_____ **Time in seconds**

14. **Reaching Forward With Outstretched Arm While Standing**

General Instruction And Set Up: A yardstick affixed to a wall via Velcro strips will be used as the measuring tool. A taped line and/or footprints are used to maintain a stationary foot position. The child will be asked to reach as far forward without falling, and without stepping over the line. The MCP joint of the child's fisted hand will be used as the anatomical reference point for measurements. Assistance may be given to initially position the child's arm at 90 degrees. Support may not be provided during the reaching process. If 90 degrees of shoulder flexion cannot be obtained, then this item should be omitted.

INSTRUCTIONS: **The child is asked to lift his/her arm up like this. "Stretch out your fingers, make a fist, and reach forward as far as you can without moving your feet."**

3 Trials Average Results

EQUIPMENT: a yardstick or ruler
a taped line or footprints
a level

( ) 4 can reach forward confidently >10 inches
( ) 3 can reach forward >5 inches, safely
( ) 2 can reach forward >2 inches, safely
( ) 1 reaches forward but needs supervision (spotting)
( ) 0 loses balance while trying, requires external support

_____ **Total Test Score**

Maximum Score = 56

Figure. No caption available.

TABLE 1.

The Berg Balance Scale and the Pediatric Balance Scale

	Berg's Balance Scale Items		Pediatric Balance Scale Items
1	Sitting to standing	1	Sitting to standing
2	Standing unsupported	2	Standing to sitting
3	Sitting unsupported	3	Transfers
4	Standing to sitting	4	Standing unsupported
5	Transfers	5	Sitting unsupported
6	Standing with eyes closed	6	Standing with eyes closed
7	Standing with feet together	7	Standing with feet together
8	Reaching forward with outstretched arm	8	Standing with one foot in front
9	Retrieving object from floor	9	Standing on one foot
10	Turning to look behind	10	Turning 360 degrees
11	Turning 360 degrees	11	Turning to look behind
12	Placing alternate foot on stool	12	Retrieving object from floor
13	Standing with one foot in front	13	Placing alternate foot on stool
14	Standing on one foot	14	Reaching forward with outstretched arm

TABLE 1. The Berg Balance Scale and the Pediatric Balance Scale

QUEST©

Quality of Upper Extremity Skills Test

Carol DeMatteo, Mary Law, Dianne Russell, Nancy Pollock, Peter Rosenbaum, Stephen Walter

Child's Name: ____________ Date: ____________ Time of Day: ________
year/month/day

Evaluator: ____________ Age: ______ years ______ months

Testing Conditions:

Room ____________

Seating (e.g., insert) ____________

Table (e.g., cutout) ____________

Orthotics (e.g., splints/AFOs) ____________

Others Present (e.g., parent) ____________

Score Key

✔ = Yes (able to complete item according to specification)
X = No (can not or will not complete item)
NT = Not Tested (not able to administer item)

If a complete section is not tested, insert NT in summary score

MAKE SURE THERE IS A SCORE ENTERED IN EVERY SCORING BOX

SUMMARY SCORE (transfer from QUEST Scoring Sheet)

A:	DISSOCIATED MOVEMENTS	☐
B:	GRASPS	☐
C:	WEIGHT BEARING	☐
D:	PROTECTIVE EXTENSION	☐

TOTAL SCORE = SUM OF SCORES FOR EACH SECTION TESTED / TOTAL # OF SECTIONS TESTED

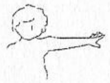
= ____________

A. DISSOCIATED MOVEMENTS
Shoulder Items

Start Position: sitting in chair — no table — hands on lap

ITEM "SHOULDER"	SCORE L <90	L ≥90	R <90	R ≥90	CRITERIA
1. Flexion	☐	☐	☐	☐	elbow: complete extension wrist: neutral to extension
2. Flexion with Fingers Extended	☐	☐	☐	☐	elbow: complete extension wrist: neutral to extension
3. Abduction	☐	☐	☐	☐	elbow: complete extension wrist: neutral to extension
4. Abduction with Fingers Extended	☐	☐	☐	☐	elbow: complete extension wrist: neutral to extension



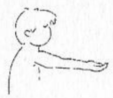



✔ ☐ X ☐ NT ☐

A. DISSOCIATED MOVEMENTS continued
Elbow Items

Start Position: sitting in chair — no table — hands on lap

ITEM "ELBOW"	SCORE L half <range	L half ≥range	R half <range	R half ≥range	CRITERIA
1. Flexion	☐	☐	☐	☐	forearm: complete supination
2. Extension	☐	☐	☐	☐	forearm: complete supination
3. Flexion	☐	☐	☐	☐	forearm: complete pronation
4. Extension	☐	☐	☐	☐	forearm: complete pronation

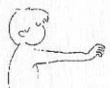



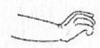
✔ ☐ X ☐ NT ☐

A. DISSOCIATED MOVEMENTS continued
Wrist Items

Start Position: sitting at table — forearms may be on table

ITEM "WRIST"	SCORE L half <range	L half ≥range	R half <range	R half ≥range	CRITERIA
1. Extension	☐	☐	☐	☐	elbow: complete extension* *see manual for definition of complete extension
2. Extension	☐	☐	☐	☐	elbow: at least 10° flexion
3. Extension	☐	☐	☐	☐	forearm: complete pronation
4. Extension	☐	☐	☐	☐	forearm: complete supination
5. Flexion	☐	☐	☐	☐	forearm: complete supination





✔ ☐ X ☐ NT ☐

A. DISSOCIATED MOVEMENTS continued
Finger Items

Start Position: sitting at table — forearms must rest on table

ITEM	SCORE L	SCORE R	CRITERIA
1. Independent Finger Wiggling 	☐	☐	dissociation of all fingers no associated reactions
2. Independent Thumb Movement 	☐	☐	no associated reactions

Grasp of 1" Cube

Start Position: sitting at table — cube at distance requiring elbow extension

Note: If Item 1 is performed, then Item 2 should also be scored YES

ITEM	SCORE L	SCORE R	CRITERIA
1. Grasp Using Thumb 	☐	☐	shoulder: neutral elbow: extension wrist: neutral to extension
2. Grasp Using Palm 	☐	☐	shoulder: neutral elbow: extension wrist: neutral to extension

✔ ☐ ✘ ☐ NT ☐

A. DISSOCIATED MOVEMENTS continued
Release of 1" Cube

Start Position: sitting at table — cube in child's hand *

*** Allowable to put cube in child's hand if he/she can't actively grasp**
Note: If Item 1 is performed, then Item 2 should also be scored YES

ITEM	SCORE L	SCORE R	CRITERIA
1. Release from Thumb and Fingers 	☐	☐	shoulder: neutral elbow: extension wrist: neutral to extension
2. Release from Palm 	☐	☐	shoulder: neutral elbow: extension wrist: neutral to extension

✔ ☐ ✘ ☐ NT ☐

Scoring for Part A: DISSOCIATED MOVEMENTS (pages 2-6)

Total ✔ : ☐ = a

Total ✘ : ☐ = b

Total NT : ☐ = c

TRANSFER TO QUEST SCORING SHEET ON PAGE I

B. GRASPS
Sitting Posture *during grasps*

Note: Observations for scoring this item should be made while administering the grasp items in the following section.

ITEM	SCORE: NORMAL	SCORE: ATYPICAL
Head	☐	☐ Left Right Flexion Extension *circle atypical posture*
Trunk	☐	☐ Forward ☐ Lateral *check off position*
Shoulders	☐	☐ Retracted ☐ Elevated *check off position*

Scoring for Part B1: GRASPS - Sitting Posture (page 7 only)

Total Normal (max. = 3) : ☐ = d

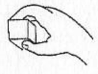
Total Atypical (max. = 5) : ☐ = e

TRANSFER TO QUEST SCORING SHEET ON PAGE II

B. GRASPS continued
Grasp of 1" Cube

Start Position: sitting at table — cube on table within comfortable reach

Note: Once a grasp has been performed, give a YES score for all those below it. If grasp observed is not listed, then score NO in all boxes and describe it under "Other" below.

ITEM	SCORE L	SCORE R	CRITERIA
1. Radial Digital 	☐	☐	wrist: neutral to extension
2. Radial Palmar 	☐	☐	wrist: neutral to extension
3. Palmar 	☐	☐	

Other:

✔ ☐ ✘ ☐ NT ☐

B. GRASPS continued
Grasp of Cereal

Start Position: sitting at table

Note: Once a grasp has been performed, give a YES score for all those below it.
If grasp observed is not listed, then score NO in all boxes and describe it under "Other" below.

ITEM	SCORE L	SCORE R	CRITERIA
1. Fine Pincer 	☐	☐	wrist: neutral to extension
2. Pincer 	☐	☐	wrist: neutral to extension
3. Inferior Pincer 	☐	☐	
4. Scissor 	☐	☐	
5. Inferior Scissor 	☐	☐	

Other: ______________________

✔ ☐ X ☐ NT ☐

B. GRASPS continued
Grasp of Pencil or Crayon

Start Position: sitting at table pencil placed midline vertical with point facing child

Note: Child must pick up pencil on his/her own.
Once a grasp has been performed, give a YES score for all those below it.

Circle one of: L Dominance R Dominance L Preference R Preference

Circle one of: grasp of Pencil grasp of Crayon

ITEM	SCORE L	SCORE R	
1. Dynamic Tripod (pencil, grasped distally - precise opposition of thumb, index & middle finger)	☐	☐	
2. Static Tripod (pencil grasped proximally - crude approximation of thumb, index & middle finger)	☐	☐	
3. Digital Pronate	☐	☐	
4. Palmar Supinate	☐	☐	

Other: ______________________

✔ ☐ X ☐ NT ☐

Scoring for Part B: GRASPS (pages 8-10)

Total ✔ : ☐ = f

Total X : ☐ = g

Total NT : ☐ = h

TRANSFER TO QUEST SCORING SHEET ON PAGE II

TEST OF VISUAL PERCEPTUAL SKILLS – 3RD Edition
Nancy A. Martin

PURPOSE: The TVPS-3 is intended to give occupational therapists, school psychologists, education specialists, optometrists, and other professionals a reliable and valid measure of a child's perceptual abilities. Since visual perceptual abilities are used in a number of academic pursuits, including learning to read, it is important to know which processes the child may be having difficulty with.
The TVPS-3 may also be used to track progress over time and for research.

POPULATION: The TVPS-3 is used to assess the visual perceptual strengths and weaknesses of students aged **4 years 0 months through 18 years 11 months.**

TEST MATERIAL: The TVPS-3 Test Materials include:
- TVPS-3 Examiner's Manual
- TVPS-3 Test Booklet
- TVPS-3 Score Sheet

TIME TO ADMIN: The TVPS-3 test takes approximately 30 minutes depending on the age of the child, and degree of difficulty experienced, as well the experience of the examiner.

TEST COMPONENTS: The TVPS-3 utilizes 112 black and white designs organized in seven subtests. The seven subtest are arranged in order of difficulty and include; visual discrimination, visual memory, spatial relationships, form constancy, sequential memory, visual figure ground, and visual closure.

ADMINSTRATION: Each of the seven subtests start with two example items (not scored), followed by 16 test items of increasing difficulty. Only in two subtests, *Visual Memory* and *Sequential Memory*, are the item presentation timed, the responses to all items are untimed. The TVPS-3 is in multiple choice format; the child indicates their choice verbally or by pointing (or by some other agreed-upon method of communication.) The subtests are administered as follows;
- **Visual Discrimination**- the child is shown a design and is asked to point to the matching design among the choices shown below
- **Visual Memory**- the child is shown (for 5 seconds) a design on one page, the page is turned, and the child is asked to choose the same design from among the choices shown on the following page.
- **Spatial Relationships**- the child is shown a series of designs on a page and asked to choose the one that is different from the rest; it may differ in a detail or in the rotation of all or part of the design.
- **Form Constancy**- the child is asked to find one design among others on the page; the design can be larger, smaller, or rotated.
- **Sequential Memory**- the child is shown (for 5 seconds) design sequences, the page is turned, and the child is asked to choose the matching design from among the choices on the following page.
- **Visual Figure Ground**-the child is asked to find one design among many within a complex background.
- **Visual Closure**- the child is shown a completed design on the page and is asked to match it to one of the incomplete patterns shown on the page.

STRENGTHS:
- Only one test booklet
- Expanding of scoring criteria (basic processes, sequential processing, and complex processes)
- Child can select response using any of the following methods (pointing to one of the designs on the page, by saying the number of the answer choice or by any other means that is understood by the examiner)
- Item choice does not require speech

- The test can be administered to children with no diagnosed disabilities as well as with children with speech, cognitive, neurological, motor or other impairments
- The test utilizes black lines against a white background, making them easy to see and eliminating any performance deficit that can be caused by colour blindness
- Gives more background information re. visual perception in Introductory Chapter in Manual
- TVPS-3 ideal for research studies

LIMITATIONS:

- Scoring can be quite difficult and confusing
- Administration can be lengthy depending on child's response rate
- The child requires good receptive language skills to complete the assessment

MAIN DIFFERENCES BETWEEN TVPS R & TVPS-3:

- Now for students 4-0 to 18-11 (TVPS-R is 4-0 to 12-11)
- New author: Nancy Martin
- No instructions or breaks between sections in book of plates
- Same seven areas of visual perception with 16 plates each
- New norms based on 2000 students
- Now 2 example plates per section instead of one
- New scoring component: basic processes, sequential processing, complex processes. Aimed to help provide more meaning to scores *still has ceiling*
- Instructions/Script in instruction book **p26-32**
- More descriptive book with information about how visual processing related to everyday processing
- Reminder to encourage students to respond even if it is a guess
- Sequential Memory Section has consistent 5 second registration time, not varied times as TVPS-R
- Appendix B: includes Norms tables

STANDARDIZATION:

- Over 2000 students were tested using this new edition
- For standardized sample demographics refer to Table 6.2 and 6.3 in Manual (*Section 6: Standardization*)

VALIDITY:

Validity refers to the degree to which theory and evidence support the stated aims of the test.

- *Content Validity*: items in the TVPS-3 were selected from previous editions of the test and included easy and difficult items from both the upper and lower levels. Information relevant to content validity appears in the Development section of the Manual (*Section 5*). Item analysis was administered to rule out item discrimination or item bias.
- *Criterion-Related Validity*: the TVPS-3 show a moderately strong correlation (0.67) to a subtest of another similar test (Visual Supplement of the Beery VMI) (See table 8.1 and 8.2 page 55 on the Manual)

RELIABILITY:

Overall reliability speaks of the precision, consistency and stability of the test over time and across examiners.

- *Internal consistency*- Cronbach's coefficient alpha and *split half coefficient* was computed for each subtest. Coefficient alphas range from 0.75 to 0.88 for subtests and 0.96 for the entire test.
- *Temporal stability*- The test-retest correlation for the TVPS-3 is 0.97, and ranges from 0.34-0.81
- *Summary of reliability studies*- The TVPS-3 has a high level of homogeneity, it provides consistent measurement from one testing to the next, and it can be consistently scored by different examiners. The TVPS-3 has a high level of reliability, and users of the TVPS-3 can have a high degree of confidence in the test's results